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Water Works Schools

By H. B. Foote

IN RECENT years many schools of instruction for water plant operators have been organized in the various states. A study of the programs of these organizations indicates that while they may have a common purpose—that of giving instruction to men in these important positions—there is a wide variation in the type of sponsoring organization, the character of instructorship, the nature of program material, and the conduct of the sessions. An opportunity, therefore, to set forth an analysis of the present situation is welcomed by the writer. May it be said at the beginning that he has, for a considerable time, had a firm conviction that such an activity as the sponsoring and holding of schools on the part of governmental agencies and established institutions of learning is well worth while and is unanimously appreciated by those directly benefited. It appears that there remains principally a question of how best to organize and conduct the school to obtain the desired results. The answer to that question will be the principal objective of this discussion.

As one reads the announcements and programs of such organizations, one's attention is called first to the variation in their names or

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A paper presented on September 17, 1940, at the Rocky Mountain Section Meeting, Denver, Colo., by H. B. Foote, Director, Division of Water and Sewage, Montana State Board of Health, Helena, Mont.

titles, of which the two most commonly used are "School" and "Conference." A formal and precise definition of these two words is perhaps the best key to an understanding of the differences in approach upon which the names are predicated. According to the dictionary meaning, a "school" is "a session of an institution of instruction" or "a place for instruction in any branch or branches of knowledge," while a "conference" is "a meeting for consultation, discussion, or an interchange of opinions." It would seem, therefore, that there is a real difference in the proposed conduct of sessions involved, between the organization which is named a "school" and that which is called a "conference."

There doubtless exists in the minds of those interested in organizing these meetings (schools, conferences, etc.) a common interest and purpose, i.e., the desirability and intention of transmitting knowledge from one who has it to another who does not. It is to be assumed, therefore, that the flow of knowledge must be in this direction if the aims are to be realized. If at the conclusion of any session this flow of knowledge stops, the source no longer disgorging, the recipient is, or should be, full of knowledge and goes his way to utilize it to the benefit of his constituents and himself.

In the case of some sessions which the writer has had the opportunity of attending, a student has gone home remembering the experiences described and has tried to duplicate them. If his situation was identical, he succeeded; if it was similar but, possibly, somewhat different, he had partial success; if it was much different, he failed. What then was the trouble? We fear that he had not been taught to study his problem, to learn first of all of what it consists, to diagnose it intelligently. Success or failure in handling a problem is basically a matter of knowledge or lack of knowledge of its underlying principles. We believe in the thesis that true knowledge is knowledge of basic principles involved and giving rise to various observable phenomena, and that an explanation of success or failure may be found in the degree of such knowledge or lack of knowledge.

To get the necessary true and usable knowledge, the student must acquire knowledge of basic principles and this requires hard work on his part. To quote a familiar phrase, "There is no royal road to knowledge." That is certainly true of knowledge in the water works field. It is not possible for any one man to know of all the experiences of everyone else, nor is it necessary that he know of them all to conduct his business properly.

In our opinion, a school or conference should, since it can usually

be held but for a few hours and at rather rare intervals, impart some knowledge of the technical language involved and enough basic knowledge to give the student or listener an enthusiasm for further home study and investigation. In his further study and reading at home, the student must be familiar with the vocabulary used. In his reading he must not stumble over strange words or phrases lest his interest and enthusiasm die and his absorption of knowledge be decreased or stopped entirely. Therefore, the school should impart to him a knowledge of and familiarity with the proper vocabulary. A glossary of terms encountered and used should be studied as diligently as a school boy studies his spelling lessons.

We do not wish to imply that the exchange of experiences between students themselves does not have any place on these programs. We believe that at least one session may well be of this nature. It provides an outlet for that very natural desire for self expression. It also encourages one in his quest for fuller information and encourages him with the knowledge that he is contributing to the common cause; but we believe that this phase of a school program should be subordinated to that of instruction in basic principles and that it can better be emphasized and expanded in an associational type of program.

To expand somewhat our meaning and its application, let us illustrate by discussion briefly the subject of odors and tastes in water. Good water is free from objectionable odor and taste. When a foreign and objectionable odor or taste, or both, appears, it may be due to one or more of several causes. Algae may be responsible, there may be a change in the chemical constituents, such as iron, dissolved in the water, or there may be present some putrescible organic material upon which biologic activity is operating. Remedial measures depend upon the basic cause. The school should give enlightenment upon all such causes which may possibly be involved. An associational type of discussion of the subject might involve an exposition of the methods employed in applying carbon in one situation or copper sulfate in another, or a discussion of the type of construction used to prevent occurrence in still another situation. The school, on the other hand, should give instruction concerning algae, plankton, bacteria, corrosion of metal, chemistry of copper sulfate and bactericidal agents, sanitary safeguards afforded by construction features, limnology, and the pronunciation and definition of words, names and terms involved. Illustrations of this nature may be multiplied. One more example will suffice. Given: (1) the desirability of distributing to customers a water of a certain satis-

factory quality; (2) the physical plant built for the purpose; and (3) a quality of water coming to this plant—we may reduce the problem to a simple equation, $\frac{A}{B} = K$, in which K is a constant representing the particular water to be distributed, A is the ability of the physical plant to deliver such a water, and B is the burden imposed upon such a plant.

As, for instance, B may be increased, A must be correspondingly strengthened, if K is to be kept constant. If the purveyor desires to improve the quality or quantity of the plant product, then perhaps A must be strengthened or increased or B must be reduced. Each factor in the equation is made up of many items, each of which must be evaluated. Now the school begins to function to enlighten the operator. He must be informed concerning each factor involved in the total of A, B, and K. Basic knowledge of water quality, hydraulics, functioning of physical plant, and the part each plays in the total problem must be obtained. The school can give him this knowledge, at least in part, and, most important of all, can give him an incentive to continue his study after the school sessions are concluded.

To a student desiring information directly applicable to a specific problem, this method may be undesirably slow and tedious, but having learned the lessons, his satisfaction in a broader understanding of, and a greater ability to judge, the factors in his situation will eventually far offset any impatience he may experience at first; and though it may involve a great deal of work and study on his part, as far as the student is concerned the method is relatively simple. He must only go to classes and apply himself to further reading and study after his course has been completed to be able to employ such knowledge as has been made available to him.

Faculty Problems

The faculty of such a school, on the other hand, faces a much more difficult problem. Each lecturer must invariably face an audience whose ability to absorb the knowledge to be imparted varies over a wide range. His fundamental difficulty will be that of satisfying the widely varying demands of a student body which includes men who have had little or no opportunity for technical study, men who are partially informed, and men privileged to have attended our highest institutions of learning, and whose need for instruction will vary

inversely with total schooling. Detailed and repetitive instruction designed for the less learned will doubtless bore the well informed, while an attempt to interest the better schooled and trained will overreach the initiates. There is no sure remedy for this situation. Patience on the part of those more fortunate must be requested and, in fact, should be expected since even the better informed person will usually profit by frequent reference to and review of basic detail.

Another difficulty which a faculty must face is that caused by the varying interests of the audience. A filter plant operator may be little attracted to a detailed discussion of drawdown in a well, or an operator of a purely gravity water system may be bored by a discussion of the hydraulics of a pump. Examples of such situations could be multiplied. Again, no sure remedy is advanced, though in many cases resort may be had to sectioning or segregating the student body with a view to grouping together those whose principal interests are similar.

Generally speaking, the personnel of the faculty should undoubtedly include men familiar with the everyday problems of students and men well versed in basic knowledge and principles underlying the work and responsibilities of the students. We believe that for the latter no better source can be found than in a state university and for the former, the engineering section of the State Board or Department of Health can usually be relied upon. In different states different agencies may be called upon for this type of service and it may be that some of the students themselves may at times become teachers.

Practical knowledge and a sympathetic understanding on the part of the faculty members are cardinal requirements. It would appear advantageous to have on the faculty the same or approximately the same members year after year. The annual experience gained by these men makes them more and more valuable as instructors as they come to see the problems of the water works man through his eyes. As a consequence, their instruction becomes, or should become, more and more practical.

Close personal association among these faculty members in their work also tends toward a greater unity of purpose on their part and is conducive to better co-ordination as to subject matter presented.

The writer has had the privilege of assisting in the organization and conduct of the school which was instituted in Montana in 1932. Nine annual meetings have been held, each lasting two days. No

attempt will be made here to detail all of the subjects treated. They have had to do with water quality (chemical, sanitary, and physical), water treatment, general sanitation, chemistry, biology, bacteriology, laboratory testing, mechanics, hydraulics, power, pumping equipment, and similar topics. The men discussing these various topics are considered qualified to lead in the studies. The same men have been associated as members of the faculty since 1933.

Montana Short School

One noticeable advantage accruing from our school has been the greater attention which the local superintendent has been able to attract to his department, raising it in the estimation of his customers and governing council members and elevating himself to a more respectable and dignified position. Needed moneys for improvements and necessary expenditures are more easily forthcoming, and while it has not served to eliminate political or other pressure, a general tendency toward giving an earnest student a freer hand in his departmental duties is observable.

We have some men in Montana who have diligently and faithfully followed the school programs, attending all sessions and getting the "extras" from instructors and associates. One can as he travels to the home communities of these men see the effects of their diligence in the improved appearances and in the greater efficiency of their water plants. Truly enough, the writer has on occasion made the same comments concerning the results of attendance at A.W.W.A. section meetings, and this leads to the following remarks concerning the Association meetings and programs.

The Montana section has met annually since 1926, and since the institution of the school, in 1932, the section programs have improved in quality and in the interest of their audiences. Another valuable result has been the more thoughtful attitude displayed by local water superintendents and operators during subsequent conferences at their home stations. These men, as a result of having attended one or more of the schools, have been more intelligent in their conduct of the business at hand, and have shown, in some cases, surprising initiative and a great reliability. In consequence, the work of the State Board of Health inspection and consulting staff has been lightened measurably. A more intelligent and sympathetic attitude toward governmental control is also evident on the part of the local authorities.

When held in connection with an associational meeting such as our sections hold, a school program can be made to supplement that of the Association. When formulating an associational program, those responsible should have the privilege of a conference with the faculty of the school, and vice versa. Thus will be secured a close co-ordination between the two, which will be of distinct advantage to those in attendance. It is well, however, to make a careful distinction between school program material and conduct and Association affairs, for they have, in effect, two distinct purposes. If the school is surrounded by an atmosphere and attitude of a school, the contrast between that and the freer atmosphere of the Association will be pleasing and profitable.

The credit for such success as we have enjoyed goes largely to members and officers of the Montana Section of the A.W.W.A. and to the self-sacrificing members of the teaching staff at Montana State College, who have been so interested and active in our development. Dr. Cogswell, Secretary, and the members of the Montana State Board of Health have encouraged the development of the school and this has aided materially in its success. We do not wish to leave the impression that we have reached the ultimate in school programs, but we are hopeful that each year will bring us a little closer to the goal of making available in a digestible and useful form, the knowledge that the student needs to do his work well.

Looking into the future we see an ever-widening influence which a water works school may exert upon those who attend and, through them, upon the life and welfare of our communities and states. The benefits so far experienced justify a greater attention to this activity and more emphasis upon this one phase of adult education. The time and money necessary can be justified without difficulty.

As the licensing of water plant operators spreads, the schools should have even a greater value in preparing men for licensing and in keeping them posted on up-to-date methods of operation.

The members of the Association can and should encourage the holding of schools and, as they are well qualified, should assist in the formation and conduct of such schools.

The author wishes to acknowledge the assistance of Dean W. M. Cobleigh of the School of Engineering, Montana State College, who, with Professor Eric Therkelsen of his staff, has been especially active in the formation and conduct of our school, and who has been of material assistance in the writing of this paper.

Report on Indiana District and Short Schools

By J. D. Richetta

FOR the past three years, the Indiana Section of the A. W. W. A. has continued to co-operate with the Indiana State Board of Health and Purdue University in the presentation of annual district water works meetings and other educational programs. The previous work in this regard was reported by Paul C. Laux (Jour. A. W. W. A., **29**: 1105 (1937). The present report covers the activities for the years 1938, 1939, and 1940, and indicates the trend toward the accomplishment of the objective announced in the earlier report. C. D. Adams, Committee Chairman, gave a report of the 1938 activities at the 1939 Indiana meeting and B. H. Jeup and W. A. Oeffler gave discussions. Mr. Adams reported the 1939 activities at the time of the 1940 Indiana meeting.

Since previous trials have indicated that best results are obtained by dividing the state into six districts, this same division has been maintained throughout the past three years, and may be used permanently. A tabulation of the number of public water supplies represented at all meetings to date reveals that the meetings are increasing in popularity. This tabulation is presented below:

YEAR	NUMBER OF SUPPLIES IN STATE	NUMBER REPRESENTED AT MEETINGS	PER CENT OF SUPPLIES REPRESENTED	NUMBER OF DISTRICTS
1935	281	77	27.4	8
1936	—*	—*	—*	4
1937	301	88	29.2	6
1938	303	97	32.0	6
1939	308	85	27.6	6
1940	323	109	36.1	6

* No data available.

A report prepared by J. D. Richetta, Senior Sanitary Engineer, Indiana State Board of Health, Indianapolis.

In order to make it convenient for the principal speakers to attend, efforts were made to have two meetings each week for three consecutive weeks, usually during the month of September. One representative from each of the three co-operating agencies attended all of the

TABLE 1

Summary of Attendance at Indiana Operators' Schools

CITY	YEAR	NUMBER OF SUPPLIES IN DISTRICT	SUPPLIES REPRESENTED AT MEETING	CLASSIFICATION				TOTAL ATTENDANCE
				Superintendents and operators	Other city officials	Professional men	Manufacturers' representatives	
Jasonville	1938	37	19	36	6	9	12	63
Bedford	"	27	8	17	3	8	0	28
Rushville	"	64	15	24	0	9	0	33
Marion	"	66	21	37	7	6	12	62
Crawfordsville	"	50	13	18	0	5	2	25
Jasper-Pulaski	"	59	21	32	6	5	1	44
Total		303	97	164	22	42	27	255
Rochester, #1	1939	60	26	36	16	8	6	66
Fort Wayne, #2	"	67	10	35	1	5	1	42
Putnamville, #3	"	51	12	16	4	4	3	27
Richmond, #4	"	64	12	31	2	7	0	40
Vincennes, #5	"	38	15	38	10	14	9	71
Clifty Falls, #6	"	28	10	16	1	7	2	26
Total		308	85	172	34	45	21	272
South Bend, #1	1940	62	26	43	9	10	9	71
Bluffton, #2	"	66	12	15	1	7	1	24
Lafayette, #3	"	57	17	24	3	5	3	35
Shelbyville, #4	"	68	19	30	2	4	2	38
Jasonville, #5	"	42	19	28	6	8	10	52
Clifty Falls, #6	"	28	16	23	0	6	0	29
Total		323	109	163	21	40	25	249

meetings, and each was scheduled on the program to deliver one of the principal talks. Speakers for the remaining subjects on the program were obtained from within the district or from manufacturers of water works equipment and materials.

One of the highlights of the meetings of 1939 was a presentation, by personnel of the Public Service Company of Indiana, of instruction in the technique of artificial respiration. The instruction was accompanied by a detailed demonstration of resuscitation procedure, all of which was received with unusual interest on the part of the water works men.

The records of attendance at the meetings during the past three years are gratifying when compared with previous records. Total attendance has been greater, and there has also been an impressive increase in the number of water supplies represented at the meetings. Table 1 is a summary of the attendance figures, and is a continuation of the tabulated data presented in the earlier report by Mr. Laux.

The slight decline in total attendance noted for the year 1940 might be attributed to the fact that 1940 was an "election" year. The records of the State Board of Health indicate that approximately 45 new water works superintendents assumed their duties during the first three months of the year.

At all of the meetings, emphasis has been placed upon fewer technical papers and more opportunity for informal discussion. At most of the meetings the superintendents presented personal problems entirely aside from the established program, and a lively discussion of these problems helped to further the object of the meetings and to expand the mutual co-operation of the groups.

The following subjects were presented at the meetings:

(1938)
1. Chlorine Handling and Uses
2. Pump Selection
3. Licensing of Water Works Operators
4. Red Water Troubles
5. Business Management of Plants
6. Additions to Distribution System
7. Safety Practices
8. Standard Practices—Services, Meters, Hydrants, Valves, etc.

(1939)
1. Residual Chlorine Determination Problems
2. Licensing of Water Works Operators
3. Leaks
4. Public Relations
5. Meter Maintenance
6. Sleeves, Joint Packing and Couplings
7. Paints

8. Water Softening Practice
9. Legal Problems
10. Emergency Artificial Resuscitation

(1940) 1. Bacteriological Tests
2. Licensing of Water Works Operators
3. Paints
4. Cold Weather Problems
5. Metering and Leak Surveys
6. Main Extensions Outside Corporation Limits
7. Residual Chlorine Determinations
8. Chlorinator Repair and Maintenance.

In addition to the regular annual district meetings, the Indiana Section also co-operated with the same agencies in the development of an annual short course for water works operators. This short course was inaugurated in 1939, and was held at Purdue University, June 19–23.

The 1939 short course was designed for operators of water works serving a population greater than 1,800. This population figure was chosen because it was not considered feasible to attempt to conduct an initial short course with the greatly diversified program which would be necessary if all water works were included. Since all of the cities in the State, as well as all but one of the water filtration plants, serve populations greater than 1,800, this grouping permitted the arrangement of a program of subjects which would be more generally applicable to everyone attending the school.

Notwithstanding the limitation placed upon attendance, it was necessary to divide the program into two sections, one for operators of water filtration plants and the other for superintendents of ground water supplies. About one-half of the program for each group was devoted to laboratory work, including demonstrations and actual experience in the use of laboratory equipment.

To present clearly to JOURNAL readers the overall aspect of the program, the periods and titles of the lectures are listed below. The names, positions and employers of the lecturers are omitted, not because great credit is not due the lecturers, but because the skeleton program as presented will serve better the specific purpose of a general reference for all JOURNAL readers. The source of each lecture is noted as follows: if a Purdue University Professor or his assistants are responsible for a lecture, it is merely noted as "University"; if a repre-

sentative of the State Board of Health gave the lecture, the designation is "State"; if a manufacturer's representative lectured, the notation is "Manufacturer"; and if a superintendent, chemist or other water plant official delivered the lecture, it is noted by "Operator."

Superintendent Section

Monday, June 19

PERIOD	
8:00–10:00 A.M.	Registration
10:00–10:30 A.M.	Introductory Remarks—State
10:30–11:15 A.M.	Water Works Information—University
11:15–12:00 A.M.	Meeting Emergencies—Operator
1:00– 2:00 P.M.	Geology of Indiana Ground Waters—University
2:00– 3:30 P.M.	Well Construction (Illustrated)—Manufacturer
3:30– 5:00 P.M.	Well Sanitation—State

Tuesday, June 20

8:00– 9:00 A.M.	Significance of 37° Count and *Esch. coli* Determinations—University
9:00–10:00 A.M.	Preparation and Handling of Laboratory Apparatus—University
10:00–12:00 A.M.	Demonstration of Bacteriological Laboratory Technique—University
1:00– 3:00 P.M.	Chlorinator Repair and Maintenance—Manufacturer
3:00– 5:00 P.M.	Meter Testing—University

Wednesday, June 21

8:00– 9:00 A.M.	General Water Chemistry—University
9:00–10:00 A.M.	Chemical Determinations in Ground Water Control—University
10:00–12:00 A.M.	Bacteriological Laboratory—University
1:00– 3:00 P.M.	Iron Removal—Manufacturer
3:00– 5:00 P.M.	Softening—Manufacturer

Thursday, June 22

8:00–11:00 A.M.	Chemical Laboratory—University
11:00–12:00 A.M.	Bacteriological Standards—University, State
1:00– 4:00 P.M.	Red Water and Corrosion—Operator
4:00– 5:00 P.M.	Distribution System Maintenance—Operator

Friday, June 23

8:00–10:00 A.M.	Cross-Connections—State
10:00–11:00 A.M.	Main Repairs and Sterilization—State
11:00–12:00 A.M.	Planning Main Extensions—University
2:00– 5:00 P.M.	Examination

Filtration Plant Section

Monday, June 19

8:00–10:00 A.M.	Registration
10:00–11:00 A.M.	Introductory Remarks—State
11:00–12:00 A.M.	Water Works Information—University
1:00– 2:00 P.M.	Significance of 37° Count and *Esch. coli* Determinations—University
2:00– 5:00 P.M.	Bacteriological Laboratory—University

Tuesday, June 20

8:00–10:00 A.M.	Repair and Maintenance of Filter Control Equipment—Manufacturer
10:00–12:00 A.M.	Repair and Maintenance of Chlorinators—Manufacturer
1:00– 3:00 P.M.	General Water Chemistry—University
3:00– 5:00 P.M.	Bacteriological Laboratory—University

Wednesday, June 21

8:00–11:00 A.M.	Coagulation Control—Operator
11:00–12:00 A.M.	Chemical Feed Equipment—Operator
1:00– 4:00 P.M.	Chemical Laboratory—University
4:00– 5:00 P.M.	Bacteriological Laboratory—University

Thursday, June 22

8:00–10:00 A.M.	Taste and Odor Control—Operator
10:00–12:00 A.M.	Care and Maintenance of Rapid Sand Filters—Operator
1:00– 2:00 P.M.	Sterilization and Its Effect on Tastes and Odors—Operator
2:00– 3:00 P.M.	Tests for Residual Chlorine—Operator
4:00– 5:00 P.M.	Bacteriological Standards—University, State

Friday, June 23

8:00–10:00 A.M.	Cross-Connections—State
10:00–11:00 A.M.	Main Repairs and Sterilization—State
11:00–12:00 A.M.	Question Box—State
2:00– 4:00 P.M.	Examination

Forty-seven superintendents and operators attended the short course, 27 being enrolled in the superintendents' section and 20 in the filtration plant section. Of the 47 attending, 38 successfully completed the final examination and were awarded certificates confirming that fact.

The 1940 short course was also held at Purdue University, the dates being June 10–12, inclusive. The instruction program was devised primarily to accommodate operators of water supplies serving less than 1,800 population, and touched only briefly on filtration processes. The following program was presented:

Monday, June 10

9:00–11:00 A.M.	Registration
11:00–11:30 A.M.	Introduction to Work—State
11:30–12:00 A.M.	Water Works Information—Where to Find It—University
1:00– 2:30 P.M.	Well Construction and Sanitation—Manufacturer, State
2:30– 4:00 P.M.	Pumps and Pump Problems—University, Manufacturer
4:00– 5:00 P.M.	Cold Weather Problems—Group Discussion

Tuesday, June 11

8:00–10:00 A.M.	Elements of Water Bacteriology—University
10:00–11:00 A.M.	Main Laying, Joints and Couplings—Operator
11:00–12:00 A.M.	Distribution System Maintenance—Operator
1:00– 2:00 P.M.	Water Main Sterilization—State
2:00– 5:00 P.M.	Hydraulic Laboratory—University

Wednesday, June 12

8:00–10:00 A.M.	Routine Chemical Control Tests—University, State
10:00–11:00 A.M.	Iron Removal and Softening—Manufacturer
11:00–12:00 A.M.	Control of Red Water—Operator
1:00– 2:00 P.M.	Elevated Tank Painting and Protection—Operator
2:00– 3:00 P.M.	Chlorination—Manufacturer
3:00– 5:00 P.M.	Examination

The short course was attended by 50 superintendents and operators, 42 of whom completed the course successfully and were issued certificates.

EDITOR'S NOTE: An outline of the Michigan State College Schedule of Courses for Water Works Operators for 1940 is given on p. 32 of the News of the Field in the May, 1940, JOURNAL. The development and administration of the Oklahoma and Texas short schools are described on pp. 28–40 of the News of the Field in the April, 1940, JOURNAL.

Certification of Operators in Tennessee

By James H. Fry

FOR the past six or seven years there has been a growing interest among water works men in some form of certification of water plant operators. The importance of the operator's responsibility as it pertains to the health and welfare of the community needs no particular comment. Its unquestioned acceptance has assured hearty approval, by the general public and by the water works profession, of any plan designed to improve the operator or to assure the continued service of a good operator.

Interest and agreement have developed among almost all water works men where some plan of certification has been proposed and discussed, and some form of certification has been put into effect in about twenty states, on either a voluntary or compulsory basis. Administration of the certification in these various states is under several different bodies, including A. W. W. A. governing committees, but many feel that the authority in all cases should be exclusively under the state health departments in each state, by virtue of their jurisdiction over water plants.

The Tennessee Department of Public Health began serious consideration and discussion of a certification plan sometime in 1937 or 1938. The possibility was proposed and discussed at the Tennessee State Operators' School in 1938, and the operators present, about 25, were asked for suggestions for working out requirements and qualifications. Finally, a plan was drawn up by the health department and presented during the year 1939. Examinations were held at the operators school and in different sections of the state in November, 1939. (Examinations were held again in November, 1940; and at present, March, 1941, there are 138 certified operators in the state.)

A paper presented on October 23, 1940, at the Kentucky-Tennessee Section Meeting, Lexington, Ky., by James H. Fry, Chief Chemist, Nashville Water Department, Nashville, Tenn.

The plan in its present form is voluntary. No state laws have been enacted to require or compel the operator to take the examination. It was thought best at the time to make the plan voluntary, because it was intended primarily to be an educational program, a policy which has been very successful in other states. The city or water company is offered a premium for co-operation in a voluntary plan in conjunction with the state department's program for approval of water supplies, where under a legally enacted plan the cities and companies would feel forced to conform and so possibly lose sight of the benefits and improvements to be derived. Although the state health department has greater legal power than it ever exercises in its supervision of local water plants, it seems to prefer to function on the theory that the enlightened co-operation of a water works is of much more value than the results brought about by the exercise of legal compulsion.

Certification Plan

The following is a quotation of the Tennessee Department of Public Health policy of certification for water works plant operators as presented on November 1, 1939:

"The following plan for the certification of water works plant operators has been developed by the Tennessee Department of Public Health and will be used as the standard in the conduct of the program in the future. The program is entirely voluntary and provides for certification for the operators of all plants in the State.

"The classifications of plants and the qualifications for operators in each group are outlined below.

Group A Plants

"This group will include all systems having coagulation, sedimentation, filtration, chlorination or other treatment processes requiring chemical and bacteriological control of operation and serving cities having more than 15,000 population.

"The operator of a Group A plant must be a graduate of a recognized college or university with a B.S. degree in engineering or chemistry, have at least one year of experience as an operator in a Group A or B plant and pass the required examination; or, in lieu thereof, he must be a graduate of an accredited high school, have special training in chemistry and bacteriology, nine years of experience as operator in a Group A or B plant and pass the required examination. Each year of college training in one of the above courses will be considered the equivalent of two years of experience. The "special training"

referred to would mean the completion of a standard course in the subject, such as would be given in a college course or a recognized correspondence school course, or experience in bacteriological and chemical procedure required in the operation of a plant in this group. The ability to perform this work as a result of experience will be determined by examination.

Group B Plants

"This group will include all systems having coagulation, sedimentation, filtration, chlorination or other treatment processes requiring at least chemical control of operation and serving cities having population between 2,000 and 15,000; and all systems having chlorination only, but serving populations in excess of 15,000.

"The operator of a Group B plant must be a graduate of an accredited high school with additional training in water chemistry and bacteriology; have at least one year's experience as an operator in a Group B or C plant, and pass the required examination; or, in lieu thereof, he must have at least an eighth grade education with special training in water chemistry and bacteriology, seven years of experience as an operator in a Group B or C plant, and pass the required examination. Each year of high school education will be considered the equivalent of one and one-half years of operating experience. The "special training" in chemistry and bacteriology would be considered the same as that outlined for Group A plants.

Group C Plants

"This group will include all systems having coagulation, sedimentation, filtration, chlorination or other treatment processes and serving less than 2,000 population; all systems using chlorination alone and serving less than 15,000 population; and all systems having no treatment and serving more than 15,000 people.

"The operator of a Group C plant must have at least an eighth grade education, have at least one year of experience as an operator in a Group C or D plant, and pass the required examination; or, in lieu thereof, he must be able to read and write, solve problems in arithmetic, have four years experience as an operator in a Group C or D plant, and pass the required examination.

Group D Plants

"This group will include all systems which are considered satisfactory without treatment and which serve less than 15,000 people.

"The operator of a Group D plant must be able to read and write,

solve problems in arithmetic, have at least one year's experience in the operation of a water works system, and pass the required examination.

"A *Certificate of Attendance*, issued by the University of Tennessee at the completion of the Water Works Plant Operators School, conducted jointly by the University and the Tennessee Department of Public Health, will be considered the equivalent of three months of operating experience. This applies to certification for all groups.

"The qualifications set forth for the operators of the several groups of plants should be considered to be *minimum* standards. It should be noted that alternate qualifications are set forth for Groups A, B, and C. The qualifications for education and experience mentioned in the first part of the specification must be considered absolutely the minimum and the stipulation that one year of educational training may be considered equivalent to a certain number of years of experience must be interpreted as applying to the alternate only.

"The educational requirements for Groups A, B, and C are waived, *provided* the applicant is regularly employed as a water works plant operator at the time the application is filed; and the application is filed before January 1, 1940.

Eligibility

"The program is open to all men actively employed as water works plant operators and to regularly employed assistant operators. The chief operator may qualify for and receive a certificate for a plant in the group next higher than his own (except chief operators in the Group A plants). Assistant operators may qualify for and receive a certificate for a plant in one group lower than that held by the chief operator. If the assistant is able to qualify for the higher certificate he will be issued a certificate in the next lower group but will be given a letter to the effect that he is qualified to operate in the higher group. The higher certificate will be issued when circumstances arise under which the higher certificate is necessary. No certificate will be issued, however, until the operator has fulfilled the experience requirement for the group in which he is operating.

Examinations

"Examinations will be given under the supervision of the Division of Sanitary Engineering of the Department at such time and place as may be designated. The examinations may be oral or written

and may include practical laboratory demonstrations. A grade of 75 per cent will be required for certification. The passing of three successive examinations at intervals of two years will be necessary before a permanent certificate is issued.

Revocation of Certificates

"The Tennessee Department of Public Health reserves the right to revoke or suspend any certificate for just cause."

State Assistance to Operators

The Division of Sanitary Engineering has gone to great lengths to provide the operators with written material and instructions concerning their work, and the state operators schools, held annually for the past nine years, have been planned to cover all the questions asked in the various examinations. In addition to this, sets of questions and answers on water works operation have been mailed to all operators monthly since January, 1940. Those who have not taken the examination yet can put this material to good use; those who are already certified may use it to continue their study for future examinations.

As the profession progresses from year to year with the introduction of new practices and new information, the material for examinations will change accordingly. It is expected that this material will become more advanced and theoretical as time goes on, in the expectation that the operator will develop with the advancement of the profession.

Form of Examinations

The examinations were given in several convenient sections of the state. A clause in the eligibility requirements waived the educational requirements in group A, B, and C provided the operator was employed in a water plant and made application before January 1, 1940. There appears to be no excuse why an operator would not welcome the opportunity to take the examinations, since no questions have been included which could not be answered by any operator familiar with his everyday work. The questions have been practical and thorough in testing the operator's knowledge and ability and have covered only those things which might arise in his work at any time. The examinations themselves can be written, oral, or in the form of a demonstration, this to be decided by the Division of Sanitary Engineering.

Benefits of Certification

There is much to be gained through co-operation in a well administered certification program. The dignity of the plant operator's profession is elevated and his position with the city or water company is made more secure. Furthermore, the operator is made more valuable to the city, and public safety in regard to water supply is greatly increased. Personnel is the most important factor in the approval of a water system. Over a third of the credits allowed in the approval score are for operation. With nine points counted for a certified operator and 90 points out of a possible 100 required for approval of a supply, it would be very rare indeed for any system to gain approval without a certified operator.

The certification plan adopted and put into operation by the State of Tennessee seems to be about the best plan that could be worked out, especially from the viewpoint of the operator. It could not be more lenient toward the operator and yet it sets up standards that will be of benefit to the operator personally as well as to the community which he serves.

Licensing Water Works Operators

1940 Staff Report

THIS Association is definitely recorded to be in favor of licensing water works operators. The resolution, adopted by the Board of Directors in 1937, stands without modification:

"The Board of Directors of the American Water Works Association, realizing the importance of efficient operation of water purification plants as a protection to public health, endorses licensing, certification, or some form of regulation of water purification plant operators and supervisors as a means of preventing the employment of incompetent personnel and assuring some continuity of employment of efficient personnel."

At the end of 1940, a questionnaire was sent to all state sanitary engineers requesting information on the status of licensing in their respective states. The information derived from their replies has been tabulated and is appended to this statement.

Arizona, Arkansas, Florida, Kentucky, Louisiana, Missouri, North Carolina and North Dakota report new developments during the year. Licenses are issued in eight states and certificates in thirteen. The action is voluntary in fifteen states, by authority of law in four, and by authority of state board of health regulation in two.

Papers or reports upon the subject of licensing, which appeared during 1940, are listed herewith:

Faust, Raymond J. Recent Problems and Developments in Michigan. Jour. A. W. W. A., **32:** 2059 (1940).

Voluntary Certification Urged at Florida Section Meeting. W. W. Eng., **93:** 712 (1940).

Clark, Lloyd K. Voluntary Certification Adopted in North Dakota. W. W. Eng., **93:** 1371 (1940).

Licensing of Operators Successful in Tennessee. W. W. Eng., **93:** 1409 (1940).

Water Works Advancement in the Southwest Through the Short Course—a Symposium: Louisiana, Frank W. MacDonald; Oklahoma, Edward R. Stapley: Arkansas, W. R. Spencer; and Texas, Lewis Dodson. Southwest W. W. J., **22:** 9: 11 (1940). *See* this issue's Abstracts.

STATUS OF LICENSING OF WATER WORKS OPERATORS IN 1940, BY STATES

STATE	LIC. OR CERT. OF OPERATORS AS OF DEC., 1940	PLAN	CLASSIFICATIONS AND REMARKS
Alabama	No		Not contemplated
Arizona	License	Voluntary	Started Sept., 1940. Movement to enact licensing into statute
Arkansas	License	Voluntary	Started 1940. License issued by water and sewage conference in 3 grades, depending on experience and examination
California	Certify	Voluntary	Certification under Calif. Section, A. W. W. A. Bill introduced into state legislature to require licensing under state health dept. No vote, still in committee
Colorado	No		Revision of licensing bill which failed to pass 1939 Legislature
Connecticut	Certify	Statutory	Qualifications of operators subject to approval of State health dept. by law. Rules for qualification set up. System is satisfactory
Delaware	No		Not contemplated
Florida	No		Enabling legislation passed by 1939 Legislature. Fla. Section, A. W. W. A., committee working out details
Georgia	Certify	Voluntary	Plan satisfactory; may lead to licensing
Idaho	No		Being considered. Pac. N.W. Section, A. W. W. A., committee studying subject
Illinois	Certify	Voluntary	"Certificate of Competency" issued by state. 4 grades: (AA) 6 yr. experience, 4 yr. college or univ. education, or equivalent; (A) 5 yr. exp., 4 yr. high school educ., or equiv.; (B) 3 yr exp., grammar school educ., or equiv.; (C) 1 yr. exp., grammar school educ. or equiv. Educ. equiv. based on exp. Grade (AA) added in 1940
Indiana	No		Bill before 1939 Legislature did not pass; may be re-introduced. Short courses initiated by State Board of Health in 1939; certificates issued for successful passing of written exams. on their completion

Iowa	No		Organization of supts. and operators to secure legislation
Kansas	No		Some discussion, but no definite plan
Kentucky	License	Voluntary	Started 1940; first exams. Aug. and Sept.; 50 qualified. Health board power of enforcement based on law passed in 1919
Louisiana	Certify	Voluntary	Adopted by La. Conf. of Water & Sewerage Plant Operators in 1940; goes into effect at 1941 summer meeting
Maine	No		Not contemplated
Maryland	No		Some discussion, but no definite plan
Massachusetts	No		Not contemplated
Michigan	Certify	Regulation of Dept.	Confirming legislation did not pass 1939 Legislature; now preparing to introduce bill before 1941 Legislature
Minnesota	No		Minn. Section, A. W. W. A., committee to investigate problem
Mississippi	No		Not contemplated
Missouri	License	Voluntary	Started in 1941. Sponsored by Mo. Water and Sewage Conf.
Montana	No		Mont. Section, A. W. W. A., interested. Legislation may be introduced in 1941
Nebraska	No		Not contemplated
Nevada	No		Not contemplated. Legislation is available
New Hampshire	No		Not contemplated. Legislation is available
New Jersey	License	Statutory	Includes all persons in direct general charge of water supply systems, as well as those in charge of purification plants. Several classifications based on type of treatment, source of supply and capacity of plant
New Mexico	No		Not contemplated
New York	Certify	Statutory in effect	Certificate of qualification issued by State Health Dept. to operators of publicly owned water treatment plants only. 3 grades of operators: (I) Chlorinators serving more than 20,000 pop., or filter plants serving more than 10,000; (II) Chlorinators serving 5,000 to 20,000 pop., or filter plants serving less than 10,000; (III) Chlorinators serving less than 5,000 pop.

STATUS OF LICENSING OF WATER WORKS OPERATORS IN 1940, BY STATES—*Concluded*

STATE	LIC. OR CERT. OF OPERATORS AS OF DEC., 1940	PLAN	CLASSIFICATIONS AND REMARKS
North Carolina	Certify	Voluntary	Started 1940. 3 grades of operators: (A) 2 to 8 yr. exp., depending on educ.; (B) 1 to 6 yr. exp., depending on educ.; (C) 0 to ½ yr. exp., depending on educ., or, for well and unfiltered surface supplies operators, who may obtain this grade certificate, 2 to 4 yr., depending on educ. Exams. for all certificates
North Dakota	Certify	Voluntary	Adopted Sept., 1940 by N. D. Water & Sew. Wks. Conf. Certification board met in Jan., 1941 to outline qualifications
Ohio	Certify	Regulation of Dept.	Certificates issued in 4 grades: (A) engr.'s license and 6 yr. exp.; (B) 3 to 6 yr. exp., depending on educ.; (C) 3 to 6 yr. exp., with lower educ. qualifications; (D) 1 yr. exp.
Oklahoma	License	Voluntary	Handled by State Health Dept.
Oregon	No		Short courses being held and ground-work laid for licensing
Pennsylvania	No		Has been discussed actively for several years
Rhode Island	No		Not contemplated
South Carolina	Certify	Voluntary	Certification by S. C. W. W. A.; approved by State Health Dept. 4 grades: (A) 8 yr. exp., or equiv.; (B) 5 yr. exp., or equiv.; (C) 3 yr. exp., or equiv.; (D) must be employed by water plant, and capable
South Dakota	Certify	Voluntary	Certificates issued by S. D. Water & Sew. Works Conf. 3 grades; higher ones not yet in effect
Tennessee	Certify	Voluntary	Certification under State Health Dept. 4 grades: (A) Filtration, more than 15,000 pop.; (B) Filtration, 2,000 to 15,000 pop., or chlorination, more than 15,000 pop.; (C) Filtration, less than 2,000 pop., or chlorination, less than 15,000 pop.; (D) No treatment. 138 "certified" operators in 96 towns; 196 systems in state

Texas	License	Voluntary	License issued by State Health Dept. 3 grades, depending on exp. and exam. passed
Utah	No		Not contemplated
Vermont	No		Not contemplated
Virginia	No		Not contemplated
Washington	No		Pac. N. W. Section, A. W. W. A., and others working on the matter
West Virginia	License	Statutory	Regulation specifically authorized by 1939 enabling law. 3 grades depending on type of treatment and population served
Wisconsin	No		Proposed legislation in 1937 failed to pass. New bill will probably be introduced, but no immediate action
Wyoming	No		Not contemplated

Mobile Laboratory Units of the Ohio River Pollution Survey

By F. E. DeMartini

IN UNDERTAKING laboratory operations connected with stream pollution surveys of large or widely separated watershed areas, the use of a central laboratory may be impracticable because of its inaccessibility to the more distant sampling points. Under these circumstances it is necessary to consider either the equipment and maintenance of several fixed laboratories, entailing a multiplied expense, or the use of mobile laboratories which can be moved over the entire area at will. The latter of these alternative procedures has many points in its favor, including greater flexibility and economy.

In 1939 a problem of this kind was faced by engineers of the U. S. Public Health Service in undertaking a comprehensive laboratory survey of the sanitary condition of the Ohio River and its tributary streams, over an area of about 203,000 sq.mi. This work is being carried on by the Stream Pollution Investigations Station at Cincinnati, in connection with the Ohio River Pollution Survey, a joint undertaking with the U. S. Engineer Corps, under the provisions of the Rivers and Harbors Act of August, 1937.

The laboratory study of the tributaries of the Ohio River involved the examination of many large streams several hundred miles in length and, in many cases, so distant from the base laboratories on the main Ohio River that the samples transported to the laboratories could not still be considered representative of the stream water when they arrived.

Three possibilities for carrying on the tributary examinations presented themselves: (1) subsidizing a considerable number of laboratories throughout the area to carry on the work; (2) training a

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large personnel and obtaining the co-operation of local laboratories to the extent of providing equipment and working space; (3) use of some type of mobile laboratory unit which could be moved from place to place in the area without too much difficulty. It was concluded that use of mobile laboratories would be the most satisfactory and economical solution to the problem.

Several state health departments have utilized mobile laboratories in recent years. In most cases they were built into bus type vehicles with their own motive power. Such units, if used also for collection of samples, have a limited usefulness due to time required for the collections. A better unit seemed to be the type developed by the Dental Service Department of the U. S. Public Health Service for use at Coast Guard Stations throughout the country. These units consist of a trailer containing all of the equipment for dental work, and a tow car to move the unit from place to place.

Use of Mobile Units

In its application to laboratory examination of stream samples, the laboratory unit or trailer is stationed at a central point for a considerable period of time (two weeks or more). The tow car is used during this period for collection of samples within a radius of about 50 miles, delivering samples to the laboratory unit. The mobile units described were designed on this basis and equipped for making the following tests:

Dissolved Oxygen	Turbidity
5-Day Biochemical Oxygen Demand	Total Agar Count at 37°C.
Temperature	Coliform Index (by dilution method)
pH	Nitrites
Alkalinity	Acidity
Soap Hardness	Iron (ferrous and ferric)

Provision of space for the necessary incubators and equipment together with adequate bench space to allow working room for two technicians governed the actual design and layout of the units. It had been decided that a three-man crew, consisting of one junior chemist, one laboratory attendant and one sample collector and chauffeur, would be necessary. Various layouts and sizes for the trailer unit were considered, the one shown in Fig. 1 being adopted finally as the best of those studied. Some of the main points brought out during the designing were that: (1) it was advisable to provide as much working bench space as possible; (2) space and load limita-

tions would not allow provision of equipment for gas heat or electric power generation; (3) a standard type of trailer shell and chassis could be used, but the interior benches and furnishing would have to be specially built for the purpose.

Early in 1939 plans and specifications for the mobile unit were prepared, bids obtained and the contract awarded to one of the commercial concerns building house trailer units.

Two units were in the field from September 12, 1939, to the end of the year, representing 27 trailer weeks of field service, in an area of 27,000 sq.mi. The total number of sample collections was 841, representing 3,364 samples.

FIG. 1. Trailer Unit and Tow Car Used on Ohio River Pollution Survey

During 1940 four additional units were obtained differing only slightly from the first two. The 1940 operations represent 161 trailer weeks of field service in an area of 103,000 sq.mi. The total number of sample collections in 1940 was 5,068, which represents 20,272 samples.

In addition, one unit made several hundred odor threshold observations in 1939–40, on a special taste and odor problem, during the winter months of December to March inclusive. This study is again being carried on this winter to compare results of last season with present conditions. A second unit is carrying on a similar study in another area where, in addition to odor tests and routine observations, phenol determinations are being made.

Specifications for Equipment

With this brief statement of accomplishments as the background upon which the experience with mobile units is based, the following comments seem justified.

In stream pollution surveys or laboratory operations involving a large field of activity, the mobile trailer laboratory has a definite place. The units described here have been used successfully to carry out the problem for which they were designed. There have been no serious difficulties with the units during this survey but certain improvements would be made in additional units. Briefly, these are:

1. Use of a heavier tow car than one of the Ford or Chevrolet classification
2. Installation of a heavy duty clutch and special transmission, having an extra low gear, on the tow car
3. Limitation of the total weight of the trailer unit, exclusive of pay-load, in order to make the vertical load on the drawbar a reasonable value, when the axle is properly located on chassis.

Some of the features provided in these units are as follows:

1. A trailer shell of the commercial type heavy frame, tires and axle, walls insulated with glass wool and all window glass of the safety type
2. A work bench 37 in. in height around the entire periphery of the unit except at the door (No space is occupied above bench-top level by incubators or fixed equipment.)
3. An acid- and alkali-resistant "karcite" sink and a lead-lined bench-top around this sink (A second small porcelain sink is provided at center of side bench.)
4. A 30-gallon water tank supplying double action pumps at each sink and a faucet at the karcite sink connected by hose line to a pressure water supply
5. A small house trailer-type built-in ice box
6. A ventilating fan in the roof vent
7. Electrical wiring in the trailer, with ample capacity to supply current for incubators, hot plates, electric muffle, etc., controlled by a load center box and an insulated copper wire cable 150 ft. long, for transmitting electric current from an outside source to the trailer unit
8. Auxiliary trailer brakes, and stop and turn signals on the trailer, all operated by switches from the tow car

9. Four jacks for leveling the trailer floor and to relieve the springs from trailer load during stops at "locations"

10. Fire extinguishers and a gasoline stove for laboratory use, supplied as part of the trailer contract.

After delivery of the units at Cincinnati, two weeks were spent in preparing them for field operations. These preparations were principally:

1. Treatment of the bench tops with acid proof stain

2. Installation of a 20°C. incubator, a 37°C. incubator and a hot-air sterilizer

3. Construction of "egg-crate" type boxes and trays for storing bottles and various items of glassware

4. Preparation of chemical reagents and bacteriological media for the beginning of field work

5. Loading of all equipment and supplies in lockers and cupboards.

It may be of interest to mention that the 37°C. incubator is water-jacketed. This type was believed to be the best for field use under varying climatic conditions and because of the heavy loading of the incubator itself. The one selected has proved to be very satisfactory and to hold its temperature uniformly in spite of adverse conditions.

The 20°C. incubator was built to specifications. An electrically-operated unit was designed to fit under the working bench. The contractor used a standard refrigerator box with a compressor unit located in the bottom section. By placing the compressor unit in a cupboard adjacent to the incubator and cutting off the lower section of the box, a full-size incubator, which would fit in the space available beneath the bench level, was obtained.

Procedure of Operation

The first two units started work on September 12, 1939. Arrangements were made in advance with some water works or sewage treatment plant in the area to be covered, preparations including the reservation of a parking space for the trailer unit, where water, power, and waste disposal facilities were convenient. Upon arrival the trailer was moved into the proper place, tow car uncoupled, trailer stabilized by means of a jack at each corner to level it and steady it against movements, rear sink faucet connected to a water supply by means of a 50-foot garden hose, and the 150-foot cable plugged into the trailer at one end and to a source of electrical energy at the other. Within a few hours incubators attained their proper

temperatures and the unit was ready to operate for any desired period.

Upon moving to a new location the incubators vary from their designated temperatures to an extent which depends upon the time involved in the move. If this is only a matter of a few hours, however, the variations are not great, as the 37° incubator has a 2-inch water jacket and the heat differential between the inside and outside of the 20° incubator is low, except under extreme weather conditions.

Average duration of work at a given location was two weeks, but in some cases stops were as long as three months. Local authorities and water works officials have been most co-operative and no difficulty has been experienced in obtaining quarters, water and electric power for the units.

The average volume of work carried on per month, by one mobile unit, is about as follows:

Number of samples collected	475
Number of bacteriological tests made	250
Number of physical and chemical tests made	850

Each collection at a station represented four samples: one for bacteriological tests, one for chemical tests, one for dissolved oxygen and one for 5-day B.O.D. Each determination is considered to be a "test." These tests include: dissolved oxygen, 5-day B.O.D., turbidity, pH, alkalinity, acidity, soap hardness, iron, nitrites, *Esch. coli*, total agar count, total solids and volatile solids.

Cost of Equipment

Costs have been estimated for obtaining laboratory results in the mobile units as compared with the Kiski (the floating laboratory on the Ohio River) and the Cincinnati Laboratory. These estimates are based on a four-year life for expendible equipment such as glassware, trailer and tow car, and an eight-year life for incubators, furniture, etc., representing a depreciation of approximately 2 per cent and 1 per cent respectively, per month. Salaries, operating costs, travel, clerical and engineering costs were also included. The cost per sample and cost per test for each of the three types of laboratory were found to be:

COST	TRAILER	KISKI	CINCINNATI
Per sample	\$2.78	\$2.26	\$1.79
Per test or determination	1.22	1.13	1.09

TABLE 1

Cost Data on Mobile Field Laboratory, Tow Car, Equipment and Six Months' Supplies

ITEM	COST	
Trailer (includes benches, lockers, 2 sinks, water tank and plumbing, 1 spare tire, 150 ft. of 60-amp. capacity wire cable, ventilating fan, 2 one-quart fire extinguishers, 4 hydraulic jacks, and 1 two-burner gasoline stove; also includes installation of helper springs and tow-iron on a coupé tow car)		$1,850.00*
Tow Car (standard 85-h.p. coupé)		649.13
Laboratory Equipment:		
1—20°C. incubator (specially built)	$230.00	
1—37°C. water-jacketed incubator	173.04	
1—pH kit, Sanitary District Chicago	53.56	
1—Electric hot-air sterilizer	45.32	
1—Colony counter, Quebec type	30.90	
1—22-quart pressure cooker	18.22	
1—Chemical balance and set of weights	12.61	
1—Artificial daylight lamp	10.00	
1—Electric heater (1,000 watts)	8.75	
1—8-inch electric hot plate	7.26	
All other equipment, such as: wire baskets, pots, pipette cans, burette holders, alcohol lamps, etc	122.06	711.72
Glassware (includes all bottles, burettes, cylinders, test tubes, flasks, pipettes, funnels, petri dishes, etc.)		231.90
Sampling Equipment:		
1—Sampling can and rope	32.00	
1—Pair rubber hip boots	5.00	
1—Sampling kit for shallow streams	10.00	47.00
Chemicals and Supplies (includes chemical supplies, dehydrated media, alcohol, gasoline for stove, towels, soap, brushes, rubber stoppers, filter paper, etc.)		80.00
Miscellaneous:		
1—50-foot length of garden hose	5.77	
1—First aid kit	2.11	
2—Laboratory stools	9.89	
1—Copy of *Standard Methods of Water Analysis*	2.58	
Lumber for trays, test tube blocks, etc	17.90	
Screen, bolts, nails, etc. for installing equipment	2.00	
Car wax, chamois, sponge, rear view mirror, etc	5.50	45.75
Total		$3,615.50

* 3% was added to this cost by the Procurement Division, U. S. Public Health Service for handling the contract. Total cost to the Ohio River Pollution survey was $1,905.50 for each of the first two trailers, and $1,256.70 each for the last four.

Costs of trailers, tow cars and equipment are shown in Table 1. A plan of the trailer units, as revised in 1940 when the second group of four units was ordered, is shown in Fig. 2. The revisions consisted

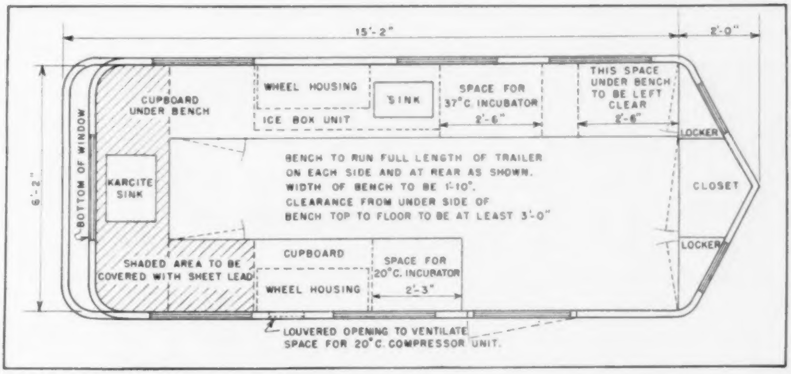

FIG. 2. Plan of Mobile Laboratory Unit Used on Ohio River Pollution Survey

NOTE: Compressor unit for 20° C. incubator is located in cupboard above wheel housing.

of: additional interior lights, provision of a ventilation opening for the compressor unit of the 20°C. incubator, extension of the lead-lined portion of the bench and an increase of 4 in. in ceiling height to 6 ft. 6 in. instead of 6 ft. 2 in.

Oregon Mobile Laboratory

By Carl E. Green

THE mobile laboratory of the Oregon State Board of Health has been designed for use in any bacteriological investigation that might be necessary in the state. It has been used during an outbreak of meningitis, for routine surveys of shellfish growing areas, for surveys of private water supplies in small towns, for special water supply investigations, and during milk sanitation rating surveys at which time both water and milk were analyzed.

The laboratory is designed for a continuous bacteriological analysis capacity of 70 water samples. At the forward end of the trailer are two bunks which have been little used. It is tentatively planned to remove the bunks and devote that space to equipment to be used for sanitary chemical analyses.

The trailer shell was purchased from the Covered Wagon Co., Mt. Clemens, Mich., through the Oregon Truckstell Sales Co., Portland, Ore. It consists of a trailer, shell only, insulated with 2-inch glass wool, and including two built-in folding bunks, and clothes closets in the front of the trailer. The laboratory facilities were installed on a contract basis after the trailer was delivered in Portland.

Immediately below are given the specifications for the trailer shell as it was ordered to be delivered to Portland; then are given the items and costs for converting it into a laboratory; and finally set forth are the items of laboratory equipment.

Specifications for Trailer

Dimensions:	Overall length, bumper to hitch	19 ft.	0 in.
	Inside length, overall	17 "	4 "
	Overall width	6 "	6 "
	Inside width	6 "	2 "
	Overall height	7 "	11 "
	Inside height	6 "	2 "

A contribution by Carl E. Green, State Sanitary Engineer, Oregon State Board of Health, Portland, Ore.

Axle: $1\frac{3}{4}$-inch molybdenum steel, 3-inch drop center, tread width of 61 in.

Springs: 12-leaf, $1\frac{3}{4}$ in. by 38 in., semi-elliptic, bronze bushed.

Wheels: Steel artillery, 15 in. by 7.60 in., 6-ply tires.

FIG. 1. Oregon State Board of Health Trailer Laboratory

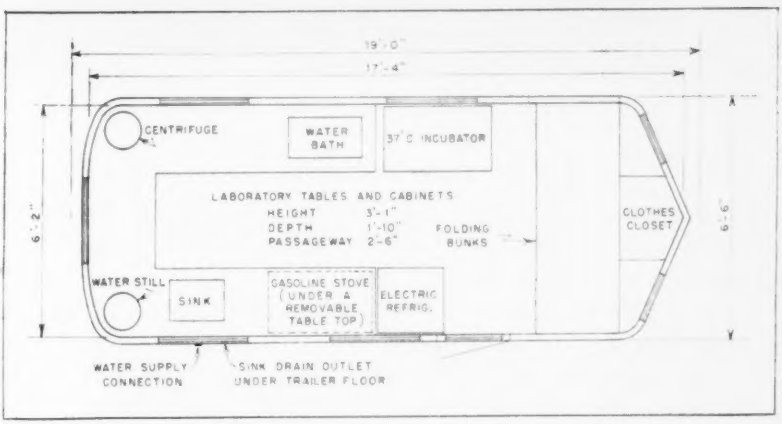

FIG. 2. Arrangement of Mobile Laboratory

Chassis: 6-inch sectional steel, automotive type, electrically welded and riveted, steel rub rail, steel cross members.

Framing: Oak, elm, and airplane spruce; $\frac{3}{4}$-inch floor.

Body Interior: Kiln dried, sealed Philippine mahogany.

Body Exterior: Shermanite steel.

Roof: Heavy water-proof canvas over padding and 3-ply plywood.

Insulation: 2-inch glass wool insulation; floor, wheel housings and ventilator insulated with Celotex.

Brakes: Warner Electric, complete with control for car.

Equipment: Includes linoleum, transformer, step, window and door screens.

Price: \$935.55 f.o.b. Portland; delivery—thirty to forty-five days from date of order.

FIG. 3. Interior of Trailer; looking toward rear

Conversion to Laboratory

Plumbing and water supply: Liquid wastes from the laboratory may be discharged either direct to a sanitary sewer through a flexible hose connection to the sink drain or to two 20-gallon covered galvanized tubs. The water supply piping is arranged for direct connection to a pressure water supply system by means of 100 ft. of $\frac{1}{2}$ inch rubber garden hose. No water storage tanks are installed in the trailer. A system of valves controls the water supply to the sink and to the distilling apparatus. Specifications are: installation of one 14 in. by 20 in. laboratory sink with traps and drains; installation of a $\frac{1}{2}$-inch galvanized water supply line with threaded inlet; cost (labor and materials), \$27.00.

Electrical: Installation of "current" meter, separate circuit for distilling apparatus, clearance lights, additional outlets, 100 ft. of extension cord; labor and materials, $60.00.

Trailer Jacks: Two Marquette Bumper type jacks to level trailer, $4.00.

Interior Cabinet Work: Construction of cabinets, laboratory tables tops, special installation of heavy equipment, stove hood, distilling apparatus, water bath, Centrifuge, (Mahogany Finish); all surfaces exposed to heat lined with asbestos and covered with stainless steel; labor and materials, $281.35.

Painting: Finishing all cabinet work, one coat of filler, three coats of water proof varnish, $42.50.

Laboratory Equipment and Supplies

Equipment:

37-degree incubator, 32 in. x 18 in. x 27 in., inside dimensions
Electric refrigerator, Frigidaire Model D3-37
Coleman stove, Model 378-A
Hot air oven, 13 in. x 17 in. x 20 in.
Pressure sterilizer, 25-quart, National Pressure Cooker
Plate Counting Apparatus, Quebec colony type
Centrifuge, International Electric, BKH* #20402
6 only 15-ml. centrifuge tubes, Pyrex, BKH 502 P
2 only reducing adapters, BKH #312
4 only 2-liter Erlenmeyer flasks, Pyrex, BKH #29136
4 only 1-liter Erlenmeyer flasks, Pyrex, BKH #29136
2 only $2\frac{1}{2}$ in. x 18 in. cylinders, glass, BKH #24650
$\frac{1}{2}$-gal. per hr. Barnstead Water still, 110-volt electric, #26122
1 only 5-gal. glass bottle, BKH #16215
1 only 2-liter aspirator bottle, BKH #16331
2 only clamps, large, BKH #21720
2 gross 1.1-ml. transfer pipettes, BKH #53080E
1 gross 10-ml. pipettes (to tip), BKH #53075E
2 doz. 1 to $\frac{1}{10}$ ml. pipettes (to tip), BKH #53075E
10 gross 6 in. x $\frac{3}{4}$ in. test tubes, Bact., BKH #60825
10 gross 2 in. x $\frac{3}{8}$ in. test tubes, Bact., BKH #60825
6 gross 5 in. x $\frac{5}{8}$ in. test tubes, Bact., BKH #60825
2 only 8-oz. alcohol lamps, burner, BKH #17820
2 only needle holders, BKH #51020
1 gross 100 mm. x 13 mm. test tubes, Pyrex, BKH #60820
1 only Harvard trip balance, BKH #12345

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* BKH refers to Braun Knecht Heimann, a scientific supply house of San Francisco.

1 only 10- to 500-gram set of weights, BKH #12710
6 only 30-ml. dropping bottles, BKH #16350
6 only 500-ml. narrow mouth bottles, BKH #16260
$\frac{1}{2}$ gross 4-oz. wide mouth glass stoppered bottles, BKH #16261
1 only counter, hand tally, BKH #23661
2 only 80-degree C. thermometers for incubator
2 only 0- to 200-degree C. thermometers

Containers for Glassware:

20 petri dish boxes, $4\frac{5}{8}$ in. x $9\frac{1}{2}$ in.
6 doz. petri dish boxes, $2\frac{3}{4}$ in. x 416 in., #10860, Central Scientific
1 wire basket constructed to fit autoclave
20 racks for water tubes $6\frac{3}{4}$ in. x $6\frac{3}{4}$ in. x $3\frac{3}{4}$ in., 36 holes in 6 rows
10 racks for water tubes, 12 holes in 2 rows
10 baskets, copper, 5 in. x $6\frac{3}{4}$ in. x 5 in.
2 baskets, copper, 4 in. x 5 in. x 5 in.
6 pipette boxes, $2\frac{1}{2}$ in. x 16 in.
1 copper pan with handles
1 metal cover for waste receptacles
6 pipette boxes, $2\frac{1}{2}$ in. x $12\frac{1}{2}$ in.

Miscellaneous Equipment: (These items total $69.72)

1 dishpan
2 metal funnels
1 ladle
1 garbage can
2 tubs, 20-gal., galvanized
50 ft. rubber hose, $\frac{1}{2}$-in. female couplings at connections
2 chairs
Blankets, sheets, etc.
1 double boiler

Supplies:

1 lb. bottle lactose broth (dehydrated)
1 lb. bottle Endos agar (dehydrated)
1 lb. bottle nutrient agar (dehydrated)
1 doz. wax pencils, Dixon, red, #71

Relative Value of 2 Per Cent and 5 Per Cent Brilliant Green Bile Confirmatory Media

By Dale Richey

A LARGE number of confirmatory media have been studied to determine their comparative practical value for use in routine water analysis. Many have proved to be valuable under certain conditions and in certain localities while others were not satisfactory when used under the same conditions. The six which are generally agreed to be the most satisfactory for routine water analysis and which are given approval in the eighth edition of *Standard Methods* are: Endo agar, eosin methylene blue agar, 2 per cent brilliant green bile*, cystal violet lactose broth, fuchsin lactose broth, and formate ricinoleate broth.

McCrady (1) has shown that the use of the 2 per cent B.G.B. medium is the most satisfactory of the confirmatory procedures, comparing very favorably with the completed test. With its development, however, investigators have been studying the confirmatory value of a 5 per cent B.G.B. medium. Although a large number of papers have been published by many investigators in regard to the use of brilliant green dye and bile salts in liquid culture media there is still some controversy regarding the relative confirmatory value of the 2 and 5 per cent bile media. This is due, in part, to the different concentrations of dye and bile salts used and to the types and location of water samples tested.

Jordan (2), with the collaboration of several laboratories, found that, as a subculture medium, 2 per cent B.G.B. was slightly superior to 5 per cent B.G.B. The individual results, however, varied a great deal indicating that B.G.B. media do not give uniform results in tests of water, from different sources, for organisms of the coliform group.

A contribution by Dale Richey, Instructor in Bacteriology, Mississippi State College, State College, Miss.

* Hereinafter referred to as B.G.B.

Dunham, McCrady, and Jordan (3) used 5 per cent B.G.B. as a confirmatory medium and found that: (1) its use eliminated the large number of Endo plates on which growth did not occur; (2) spore-forming organisms were eliminated; and (3) the per cent of brilliant green cultures to lactose broth cultures was 99.5 per cent. With the use of filtered water, filtered water after chlorination, and tap water, they noticed that the B.G.B. medium did not inhibit any organisms of the coliform group.

Levine, Carpenter, and Coblentz (4), in their study of bacteria isolated from chlorinated water, noticed that of 100 strains which produced gas in lactose broth, 6 per cent were inhibited when inoculated into 2 per cent B.G.B. and 9 per cent when inoculated into 5 per cent B.G.B.

Butterfield (5) states that the favorable results obtained with B.G.B. media (either 2 or 5 per cent) warrant its use as a confirmatory media in locations where it has proved efficient.

The inhibition of spore-forming organisms by the use of B.G.B. media is well known, but there is still some controversy over the relative inhibitory effect of the 2 and 5 per cent media. Hale (6) regards the 2 per cent medium as having too low a concentration of brilliant green to prevent growth with gas formation by *Clostridium welchii*; and the use of the medium would be of little value if spore-forming organisms were permitted to grow. Greer *et al.* (7), using Lake Michigan water, noticed that both 2 per cent and 5 per cent B.G.B. were highly inhibitive to *Clostridium welchii.* Levine, Carpenter, and Coblentz (4) found that, of twelve lactose fermenting aerobic spore-forming organisms isolated from chlorinated water, two produced gas in 2 per cent B.G.B. and none in 5 per cent B.G.B.

The following data have been obtained to determine the relative value of 2 per cent and 5 per cent B.G.B. as confirmatory media both in gas confirmation and the usual agar plate completed method, on waters of the far South.

Outline of Work

The materials needed for the problem were obtained, in dehydrated form, from the Difco Laboratories of Detroit. The laboratory procedure specified for the comparative work is as follows:

1. Plant five 10 ml. portions and five 1 ml. portions of water sample in lactose broth and incubate 48 hr. at 37°C. If, and as soon as, any gas appears in each tube, transfer a loopful to (a) 2 per cent B.G.B., and (b) 5 per cent B.G.B., and incubate for 48 hr. at 37°C.

2. Confirm "completely" (using eosin methylene blue agar, secondary lactose broth, agar slant, etc.) from the primary lactose broth, the 2 per cent B.G.B., and the 5 per cent B.G.B. as soon as any gas appears.

A total of 103 water samples, collected from a wide area over the State of Mississippi, was used for this problem. The majority of water samples were obtained from untreated deep and surface wells. Less than 10 per cent of the water samples, known to be polluted, were from open top bucket lift wells.

A summary of the results of the study will be presented in two parts: (1) a comparison of the two bile media with the *Standard Methods* lactose broth; and (2) a comparison of the two bile media.

TABLE 1

Results of Three Different Methods of Confirmation of 441 Lactose Broth Presumptives Obtained From 103 Water Samples

CONFIRMATION PROCEDURE	1 POSITIVE PRESUMPTIVES	2 COLIFORM ORGANISMS ISOLATED		3 COLIFORM ORGANISMS WHICH WERE NOT ISOLATED DIRECTLY BUT WERE SHOWN BY ONE OR BOTH OF THE OTHER MEDIA TO CONTAIN THEM		4 SUM OF COLUMNS 2 AND 3—TUBES CONTAINING OR PROBABLY CONTAINING COLIFORM ORGANISMS	
		No.	Per Cent*	No.	Per Cent*	No.	Per Cent*
S.M.C.†	441	317	71.9	42	9.5	359	81.4
2% B.G.B. + (S.M.C.)	358	326	91.6	18	5.0	346	96.6
5% B.G.B. + (S.M.C.)	358	335	93.5	21	5.8	354	99.3

* Per cent of presumptives.

† S.M.C. signifies the *Standard Methods* "completed test" procedure.

Procedure

Lactose broth presumptives were confirmed by the three methods, the aggregate results of which are given in Table 1. In Columns 1 and 2 of the table, the figures show that the *same number* of confirmatory presumptives were obtained with the two brilliant green bile media, but that the greatest number of coliform isolations was obtained from the 5 per cent medium. Also demonstrated is the fact that the proportion of the presumptives which yielded coliform isolations was greater with the 5 per cent medium.

The figures of Column 3 represent the number of lactose broth tubes that yielded no coliform isolations by the particular procedure

in question, but from which they were isolated by one or more of the other methods. Forty-two lactose broth presumptives failed to yield coliform organisms by the usual completed test but were shown by one or both of the selective confirmatory media to contain the organisms. By means of the confirmatory procedure, an additional 9.5 per cent of the lactose broth presumptives were shown to contain coliform organisms.

In the case of the 2 per cent B.G.B. medium, 18 tubes, or 5 per cent of its presumptives failed to yield coliforms by the procedure in question, but were isolated by one or more of the other methods.

The number and proportion of tubes when the 5 per cent B.G.B. medium was employed were 21, or 5.8 per cent of presumptives. It should be noticed in Column 3 that, as confirmatory media, the two bile media gave results which were very similar.

TABLE 2

Results of the Three Methods of Confirmation in Percentages of Total of 359 Sample Portions From Which Coliform Organisms Were Isolated by One or More of the Three Methods

CONFIRMATION PROCEDURE	CONFIRMATIONS	COLIFORM ORGANISMS ISOLATED
	%	%
S.M.C.	88.3	88.3
2% B.G.B.	99.7	90.8
5% B.G.B.	99.7	93.3

The sum of Columns 2 and 3 is shown in Column 4. The two bile media show a high proportion of confirmed presumptives that is of particular interest, the 5 per cent B.G.B. having a slightly higher porportion than the 2 per cent medium. When the 5 per cent B.G.B. medium was employed, 99.3 per cent of its presumptives were proved, by the use of the three confirmatory methods, to contain coliform organisms.

The figures in Table 2 represent the proportion of the number of sample portions from which coliform organisms were isolated by any of the three confirmatory methods. It will be observed that the usual completed test detected the presence of coliform organisms in only 88.3 per cent of the sample portions known to contain them. On the other hand, both 2 per cent and 5 per cent B.G.B. indicated the presence of the group in 99.7 per cent of the number of sample portions known to contain coliform organisms.

The figures in Column 2 show that 5 per cent B.G.B. yielded a greater proportion of coliform isolations than either the 2 per cent B.G.B. or the usual completed test method, yielding 335 isolations, or 93.3 per cent of the tubes known to contain coliform organisms.

The number of presumptives of each of the selective media from which coliform organisms were not isolated by the usual completed test, and the number of these from the corresponding lactose broth primary of which coliform organisms were isolated by one method or another, are shown in Table 3. The figures in Columns 1 and 2 show that the usual completed test gave a large number, 124, of non-confirming presumptives; and 42, or 33.8 per cent, of these non-confirming presumptives were proved, by means of other broths, to contain coliform organisms.

TABLE 3

Non-Confirming Presumptives

CONFIRMATION PROCEDURE	NON-CONFIRMIMG PRESUMPTIVES	NON-CONFIRMING PRESUMPTIVES FROM THE CORRESPONDING L.B.P. OF WHICH COLIFORM ORGANISMS WERE ISOLATED BY MEANS OF OTHER BROTHS	
	No.	No.	Per Cent
L.B.P.*	124	42	33.8
L.B.P. + 2% B.G.B.	30	18	60.0
L.B.P. + 5% B.G.B.	25	21	87.5

* L.B.P. signifies lactose broth presumptive.

In the case of the two bile media 60.0 per cent and 87.5 per cent of the non-confirming presumptives of 2 per cent and 5 per cent B.G.B., respectively, were proved by the other methods to contain coliform organisms.

The degree of error resulting from the usual completed test and the saving of time, labor, and equipment by the use of either of these confirmatory media are well illustrated in the figures of this table.

Comparison of Individual Results

Table 4 represents a comparison of the individual results of the three confirmatory procedures to avoid the counter-balancing of negative and positive errors which occur in the compilation of aggregates. The difference between the number of positives indicated by each method of confirmation and the number of sample portions

from which, by any method, coliforms have been isolated, is computed for each sample. All positive differences are summed to give a total which is designated as the "positive cumulative error," and all negative differences are likewise summed to give the negative cumulative error. For example, if, through the use of all of the confirmation methods, coliform organisms are isolated from six portions of a sample, whereas the 2 per cent B.G.B. method indicates eight portions to be positive, the error due to the use of the method is recorded as plus two. All such results are added together to give the positive cumulative error of the method. It is to be noted that, since the usual completed test, unlike the selective methods, does not record non-confirming lactose broth presumptives as positives, no positive cumulative error is referable.

TABLE 4

Cumulative Errors of Results From the Three Confirmatory Procedures (Presence of Gas Alone Is Considered to Constitute Confirmation)

CONFIRMATION PROCEDURE	CONFIRMATIONS			
	Positive		Negative	
	No.	Per Cent	No.	Per Cent
S.M.C.			42	11.72
2% B.G.B.	12	3.34	28	7.80
5% B.G.B.	15	4.17	24	6.68

In the table are shown the cumulative errors of the results obtained by each confirmatory method from 441 lactose broth presumptives. The negative cumulative error for the *Standard Methods* completed test was greater than that for either the 2 per cent or the 5 per cent B.G.B. methods. This negative error means that the usual completed test failed to detect coliform organisms in 11.72 per cent of the presumptives in which they were present.

The positive cumulative errors of the two bile media are very similar. In the 2 per cent method, twelve, or 3.34 per cent of the total of complete confirmations, gave positive presumptives from which coliforms were not isolated by any of the confirmatory procedures. The same error for the 5 per cent method was 15, or 4.17 per cent.

The positive cumulative error of any presumptive confirmatory procedure must be very small compared with the total number of

sample portions shown to contain coliform organisms. The negative cumulative error must be as small as possible and, preferably, not greater than that of the usual completed test; otherwise, too many instances of contamination may be overlooked.

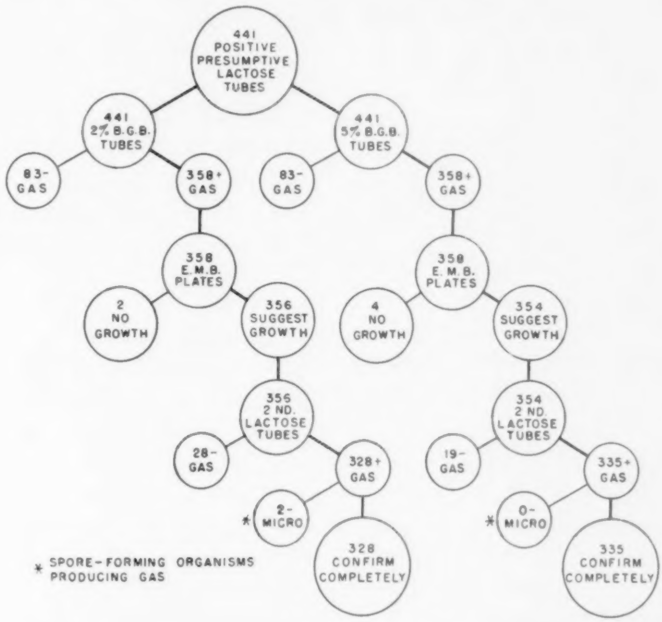

FIG. 1. Comparison of 2 per cent and 5 per cent B.G.B.; showing experimental data obtained

Comparison of Two Bile Media

The comparative results of the two confirmatory media are shown in graphic form in Fig. 1. It is to be noted that, from the 441 lactose broth presumptives, an equal number, 358, positive gas tubes were obtained from each of the bile confirmatory media. When streaking on eosin methylene blue agar, a loss of two positive gas tubes was encountered with the 2 per cent B.G.B. method, and a loss of four positive tubes with the 5 per cent method.

Transfer to secondary lactose tubes from the 2 per cent and 5 per cent media gave only 28 and 19 failures, respectively, to produce gas. Complete confirmations were quite similar for both media, 326 tubes completely confirmed by the 2 per cent method and 335

tubes by the 5 per cent method. It will be remembered from Table 1 that the proportion of coliform organisms isolated from the 358 positive presumptives of each of the bile media was 91.6 per cent for the 2 per cent media and 93.5 per cent for the 5 per cent media. These results show that 5 per cent B.G.B. proved slightly better than 2 per cent B.G.B. as a liquid confirmatory medium.

The relation of 24-hour gas production to the isolation of coliform organisms is illustrated in Table 5.

After transferring from the lactose broth presumptives to the 2 per cent B.G.B. medium, 344 tubes showed positive gas production in 24 hr., with 322 tubes confirming, thus giving a proportion of 93.6 per cent. Likewise, the 5 per cent B.G.B. medium gave 351 positive gas tubes in 24 hr., with 324 confirming, for a proportion of 92.3 per cent.

TABLE 5

Relation of Gas Production to Isolation of Coliform Organisms by the Use of 2% and 5% B.G.B. Media

CONFIRMATION PROCEDURE	GAS—24 HR.	COLIFORM ORGANISMS ISOLATED		GAS—48 HR.	COLIFORM ORGANISMS ISOLATED	
	No.	No.	Per Cent	No.	No.	Per Cent
2% B.G.B. (S.M.C.)....	344	322	93.6	358	326	91.6
5% B.G.B. (S.M.C.)....	351	324	92.3	358	335	93.5

In examining the figures for the 48-hour gas production, it is to be noted that a slightly smaller proportion of coliform organisms were isolated after 48-hour gas production with the 2 per cent medium. Also, it is to be noted that the 5 per cent B.G.B. medium had a slightly larger proportion of coliform organisms isolated after 48-hour gas production than it had after 24-hour gas production. These results are understandable, since in Table 3 it was shown that the 2 per cent medium had a larger number of non-confirming presumptives than did the 5 per cent B.G.B.

Taking gas production alone as indication of the presence of coliform organisms, the two confirmatory media could both be employed for the purpose as there seems to be very little difference in their relation between gas production and coliform organisms isolated.

Summary and Conclusions

The results of the present study of 2 per cent and 5 per cent B.G.B. indicate that either media would serve, in most laboratories doing

routine water analysis in the South, as a reliable medium for use in the simpler confirmatory procedures. The 5 per cent B.G.B. medium, however, is superior to the 2 per cent medium in number and per cent of coliforms isolated, and both media gave better results than did the usual completed test. On the basis of all isolations secured, 5 per cent B.G.B. yielded 93.3 per cent, 2 per cent B.G.B., 90.8 per cent, and the usual completed test, 88.3 per cent of the total number of coliforms isolated.

From the standpoint of individual results, the 5 per cent B.G.B. confirmatory procedure had the smallest total cumulative error, although it was only slightly smaller than that of the 2 per cent method.

Any simple confirmatory procedure that gives a high proportion of coliform isolations in relation to gas production would be, unquestionably, of immense value in routine water analysis. The relation of gas production to isolation of coliform organisms by the use of these two B.G.B. confirmatory procedures is high, indicating that either is very specific for the coliform group of organisms. Without doubt, much time and labor could be saved by employing either of these media as confirmatory procedures, and, using them, the technician would be justified in assuming, from the presence of gas alone, that coliform organisms would be present.

The relative ability of these two B.G.B. media to eliminate spore-forming organisms is very similar. The 5 per cent B.G.B. procedure, however, did not support the growth of a single spore-forming organism while the 2 per cent medium supported the growth of two.

The conclusions reached from these experiments are as follows:

1. The 5 per cent B.G.B. medium is slightly superior to the 2 per cent medium in the number and proportion of coliform organisms isolated.

2. The proportion of coliform organisms isolated from tubes that were shown by one or more of the three confirmatory procedures to contain such organisms was greater when using the 5 per cent medium than with the 2 per cent medium.

3. The 5 per cent B.G.B. method gave the smallest total cumulative error.

4. The high proportion of coliform isolations to gas positive tubes by the use of either of the B.G.B. media indicates that both are very specific for the coliform group of organisms. A great deal of time and labor could be saved by adopting either of these procedures; and for the examination of most waters in the South, either of the

methods, could be used to advantage to replace the usual completed test.

5. The 5 per cent B.G.B. medium is slightly superior to the 2 per cent medium in the inhibition of spore-forming organisms.

The author wishes to express his appreciation to M. H. McCrady for his suggestion of the problem, and for his helpful criticism and advice.

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Racine Method of Residual Chlorine Determination

By John J. McCarthy

THE determination of residual chlorine is probably the most abused and, to a great extent, the most inaccurate of all the determinations made in the process of water purification. Certainly it is, as a whole, the least understood. All one must do to be convinced of these facts is to visit a number of filtration plants and to note the various methods and apparatus used in making such determinations.

The reasons for the great variations from standard procedure seem to be fairly evident. First, the use of so-called original ideas, combined with the fact that raw waters are not the same, leads to many different approaches to the subject. Then, too, the methods and possibilities for chlorine treatment vary widely and economic set-ups are often entirely different. All these factors have a profound effect on the choice of procedure. Some plants, for instance, are administered by progressive commissions or boards who feel that the only way to achieve a 100-per cent return on the investment is to make that investment bring results by operating with competent men and the best instruments and tools obtainable, while in other plants the operating cost is cut to an absolute minimum, so that only the ingenuity of the operators can make controlled water purification possible.

Regardless of the method used for determining chlorine residual, however, there must be a constant replacement and fresh preparation of standards. Since its adoption into *Standard Methods*, the determination of chlorine residual in drinking water by the orthotolidine method, has been the object of considerable study. The yellow color that is produced on treating an aqueous solution of

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A paper presented on October 16, 1940, at the Wisconsin Section Meeting, Manitowoc, Wis., by John J. McCarthy, Director of Laboratories, Racine, Wis.

chlorine with ortho-tolidine is accepted as being the result of an oxidation process. Various factors, such as temperature, time of contact between the chlorine and the reagent, presence or absence of bright light, and hydrogen ion concentration are known to produce varying intensities of yellow and yellow hues, ranging from greenish yellow to orange yellow. Moreoever, the human equation, or the ability of the technician to compare colors must also be considered a factor in determining the accuracy of this method.

The inaccuracy of the eye in matching the intensity of colors is only too well known. This difficulty is not so marked in the blue and purple end of the color scale, but is very pronounced in the red-yellow part. Also, the human eye is subject to the many imperfections that any other part of the body may undergo, imperfections being more accentuated in different individuals. Consequently, eye colorimetry, even in the blue end of the color scale, is far from being all that might be desired, while in the red end of the color scale it is often entirely unsatisfactory.

It might be valuable to digress here to note that colorimetric chemistry is that phase of the science which deals with the quantitative analysis of chemicals in terms of their color reactions. These color reactions are the results of special treatment, of the substance being analyzed, with a reagent which is often very complicated and which produces a color reaction whose intensity varies in relation to the quantity of the substance. Such analyses involve many technical factors which influence the degree of precision of the readings, and, even when handled with the extreme care and caution of a skilled analytical chemist, they are not free from erratic results.

Photo-Electric Colorimetry

Development in spectrophotometric methods has led to a new method of colorimetric analysis known as photolometry. Photolometry is based on the use of a photo-electric cell, which offers an indisputably more precise means of measuring light intensity than the human eye, and which, in this application, eliminates one of the undesirable human elements from a routine scientific measurement. The photo-electric cell, however, does not measure the intensity of colors as such. It measures the degree of transmission of light, and, therefore, reacts similarly to all colors, though it is somewhat more sensitive to blue and purple shades. Its introduction into the field of water works chemistry might be considered an important step and its application may introduce an era of more accurate routine analysis.

It is not the author's purpose to introduce a new type of photoelectric colorimeter, but rather to make available to the average water filtration plant operator an instrument that will be less expensive and that will still render results within the degree of accuracy demanded by the water works profession. With the instrument to be described here (Fig. 1) it was possible to obtain color density readings without intercomparison with a set of standards, thus making it possible to measure accurately the influence of such factors as treatment technic, temperature, time, concentration or reagents, etc.

The construction of this electric colorimeter was prompted by the variations in the chlorine determinations as made with the inter-

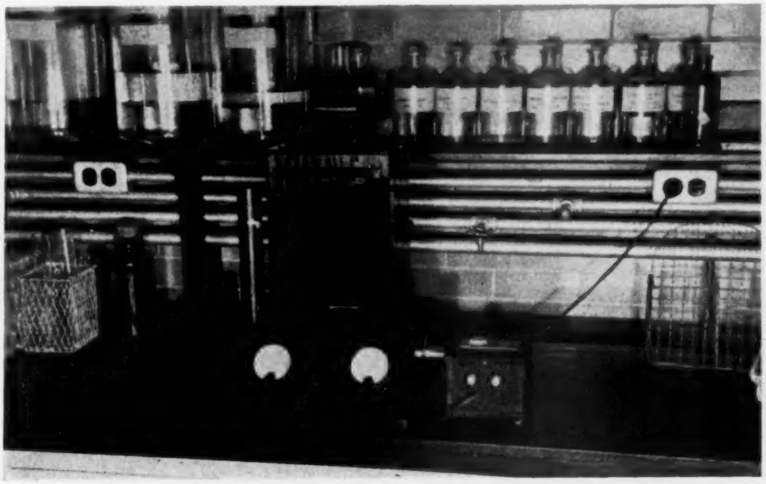

FIG. 1. Racine Photo-Electric Colorimeter

comparison of a set of color standards by an operator. While the operators in the Racine plant are not trained laboratory technicians, they are, nevertheless, capable of performing quantitative determinations within a reasonable degree of accuracy. So long as it was necessary to depend upon the operator's eyes to determine the concentration of orange yellow and green yellow in varying amounts, however, it was known that there could never be a 100-per cent agreement.

When it was decided to make such determinations photometrically, special consideration was given to the existing instruments and to the way they were going to be used and by whom. The representative of a scientific supply company was approached with the idea of

making a more durable instrument, but, while his organization was amenable to the idea, the demand did not warrant the expense entailed to manufacture it. It was then decided to design, specifically for the use of the Racine plant, an instrument which would be durable, accurate and simple; which would record more accurately the amounts of chlorine residual than the existing comparative method; which would employ standard parts and be simple enough to be understood by the operators; and which could be repaired or adjusted by the operator.

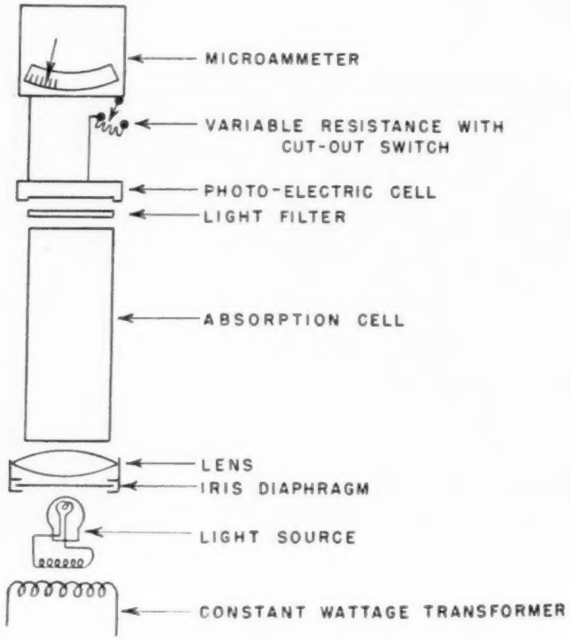

Fig. 2. Details of Racine Photo-Electric Colorimeter

Specifications for Colorimeter

Consideration was given to the various types of photo-electric tubes, photo-electric cells, etc., and the simplest type—a single cell unit—was chosen. Its operation, as that of all photo-electric colorimeters, is based on the Bouguer-Beer law, which relates the concentration of a substance in solution to the light transmission factor of the solution.

Figure 2 is a schematic diagram of the instrument, showing the various parts, as follows:

1. The transformer, which supplies a constant 6.2-volt alternating current to a 45-watt load from a 60-cycle alternating current source in which the voltage fluctuates.

2. The light source, a 50-candle-power, 6- to 8-volt head-light lamp.

3. The iris diaphragm, part of a microscope condenser, which may be replaced with a diaphragm obtained from a camera repair shop at a cost of $1.00.

4. The lens, which is a part from an inexpensive pair of binoculars.

5. The absorption cell, a 100-ml. low-form Nessler Tube. (A collar is fitted around the top edge of the cell to prevent the light from passing through the wall of the cell and thereby energizing the photo-electric cell.)

6. The filter, which is a deep blue pyrex glass.

7. The photo-electric cell, a Type 1 Photronic cell, manufactured by the Western Electric Instrument Corp. (Photronic cells are entirely electronic in their action. When light impinges on the sensitive surface, which is directly behind the glass window, an electric current is set up, producing its own e.m.f. at the terminals of the cell, and causing the current to flow through an external circuit such as the galvanometer or microammeter. The total current generated in the cell is a function of the illumination and is proportional to it.)

8. The resistance, a 5,000-ohm variable unit similar to the type employed in radio construction, used to standardize the light source.

9. The galvanometer or microammeter of the pointer type. (The scale has 60 divisions of 1 mm. each; sensitivity per millimeter division is 0.10 microamperes; approximate coil resistance is 1,100 ohms; external critical damping resistance is 8,000 ohms; and the period, 4 sec. This galvanometer is rugged and at the same time very sensitive.)

Data on Operations

In the operation of the apparatus, the instrument is first allowed to heat for 15 min. (for accurate work) to permit the output of the cell to become constant. The output is then adjusted to some definite value with distilled water in the interposed cell. The cell is then filled with a solution of a known concentration of chlorine and the conduction observed. A curve is plotted using a number of solutions

of known concentrations of chlorine. The calibration curve is plotted on semi-logarithmic graph paper. The known concentrations of solutions are plotted as ordinates in the equal-division axis against the microammeter readings as abscissas in the logarithmic scale.

Stock chlorine water is prepared by bubbling chlorine gas into distilled water and storing in a dark bottle or container. The concentration of the stock solution is determined by titration with standard sodium thiosulfate. Zero water or distilled water showing no chlorine demand is to be used in making dilutions.

McCrumb* has shown that ortho-tolidine in the oxidized form acts as a neutralization indicator, its hue changing from yellow to blue through the pH range 2.0 to 3.5. From this it is apparent that

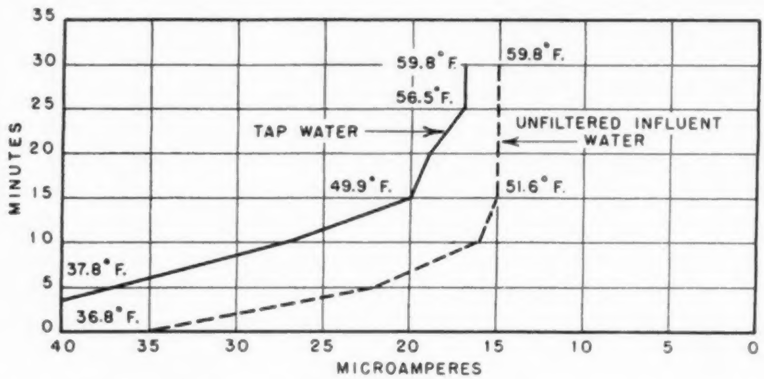

FIG. 3. Influence of Temperature on Speed of Oxidation Reaction; using a cold solution (2.0 ml. added to both samples)

varying shades of ortho-tolidine yellow will be produced unless the final pH of the solution is constant or lies outside the range of color change. *Standard Methods* specifies the use of 1 ml. of ortho-tolidine reagent (10 per cent HCl by volume) per 100 ml. of water tested. This amount is assumed to provide a satisfactory pH value. Experiments show, however, that this amount of acid is hardly enough for Lake Michigan water. McCrumb found that when a sample of tap water having a pH of 7.67 was treated with 1 ml. of standard reagent, the resultant solution had a pH of 2.24. Probably a more alkaline water or one of greater hardness would show a pH value as high as 2.5 after treatment. The greenish yellow hue is developed whenever

* McCRUMB, F. R. Elimination of Errors in Ortho-tolidine Method. J. N. E. W. W. A., **41:** 386 (1927).

the pH is between 2.0 and 2.5. The true ortho-tolidine yellow is developed only when the final pH of the solution is below 2.0.

The tap water at the Racine plant varies between a pH of 7.6 and 7.8, depending on the weather. When the pH was 7.73, 1 ml. of ortho-tolidine reagent in 100 ml. raised the hydrogen ion concentration to pH 2.14 and 2 ml. raised it to a value of 1.83.

With the colorimeter, it was possible to check the results of other investigators and to show the results graphically. In Figs. 3 and 4 is demonstrated the influence of temperature on the speed of the oxidation reaction. The curves in Fig. 3 start with a cold solution, and as the curves move toward the right, the color increases and the photo-electric cell receives less energy, as is registered on the

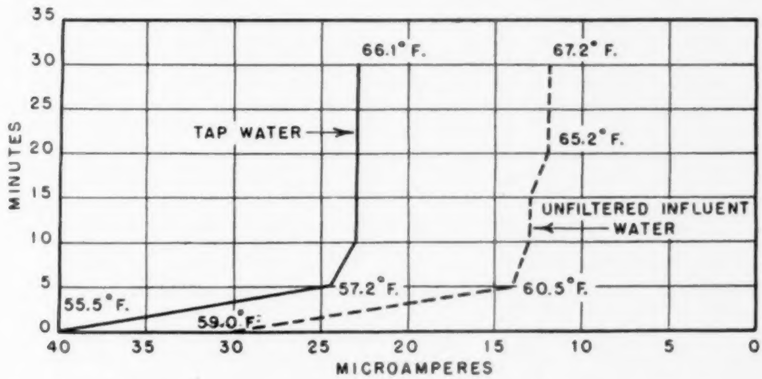

FIG. 4. Influence of Temperature on Speed of Oxidation Reaction; using a warm solution (2.0 ml. added to both samples)

galvanometer. The curves are gradual until the temperature of the solution reaches a temperature of about 55°F. The reaction seems to be just about completed at that point. In an additional 15 min., the unfiltered water shows no increase in color and very little in the tap. In Fig. 4 the curves start with a warm solution and the reaction is very nearly completed in 5 min. The photo-electric cell records small changes that sometimes pass unnoticed where comparison tubes are used.

The concentration of ortho-tolidine reagent in the solution and its effects are shown in Figs. 5, 6, and 7. Curves in Fig. 5 begin with a cold solution. The shorter time to complete the reaction occurs where the concentration of ortho-tolidine reagent is greatest but as the solution reaches 55°F. the reaction is completed with all con-

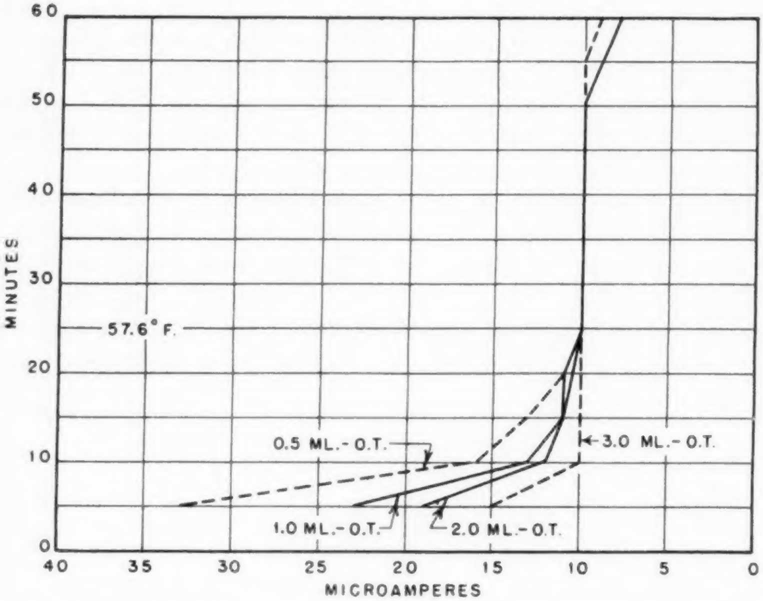

FIG. 5. Effects of Various Doses of Ortho-tolidine in Solution of Unfiltered Influent Water; start—33.9°F., finish—57.6°F.

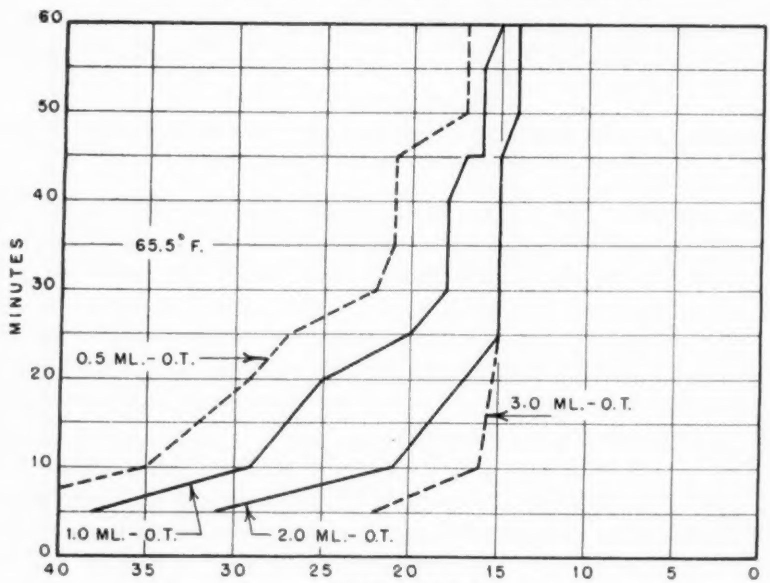

FIG. 6. Effects of Various Doses of Ortho-tolidine in Solution of Tap Water; start—37.5°F., finish—65.5°F.

centrations of ortho-tolidine reagent. In Fig. 6, it is to be noted that the 55°F. temperature and 20-minute period did not hold good for the two smaller concentrations of ortho-tolidine reagent, but that they did for amounts of 2 and 3 ml. In Fig. 7, the curves follow the same general trend as in Fig. 5, the water with the higher concentrations of the reagent developing the maximum depth of color within 30 min.

The curves in Figs. 8 and 9 demonstrate the effect of having the pH of the solution at 2 or less, though the data of Fig. 8 do not show this

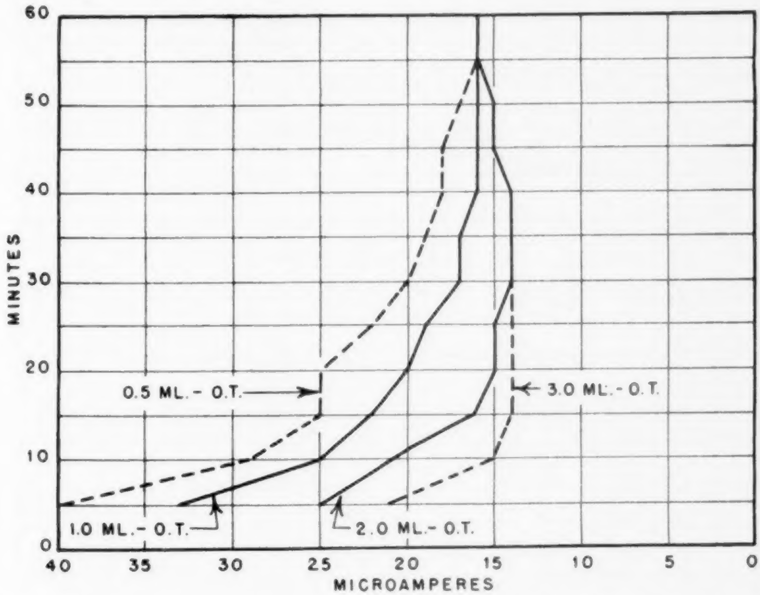

FIG. 7. Effects of Various Doses of Ortho-tolidine in Solution of Tap Water; start—37.9°F., finish—71.5°F.

as clearly as those of Fig. 9. In these curves 0.5 ml. of reagent plus the 1.5 ml. of 10 per cent HCl would be equivalent to the HCl concentration in 2 ml. of ortho-tolidine reagent. This demonstrates clearly that when the acidity of the solution is pH 2 or less, the reaction will be completed in 20 min. provided that the temperature of the solution is 55°F. or above.

Adams and Buswell† found that at the end of the 20-minute period

† ADAMS, HOWARD W. AND BUSWELL, A. M. The Ortho-tolidine Test for Chlorine. Jour. A. W. W. A., **25:** 1118 (1933).

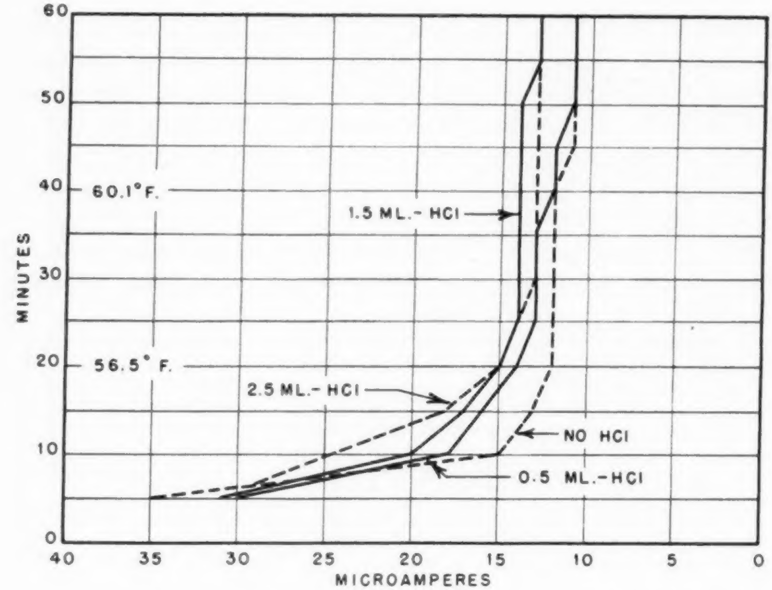

FIG. 8. Effect of Low pH of Solution of Unfiltered Influent Water; start—33.5°F., finish—60.1°F.

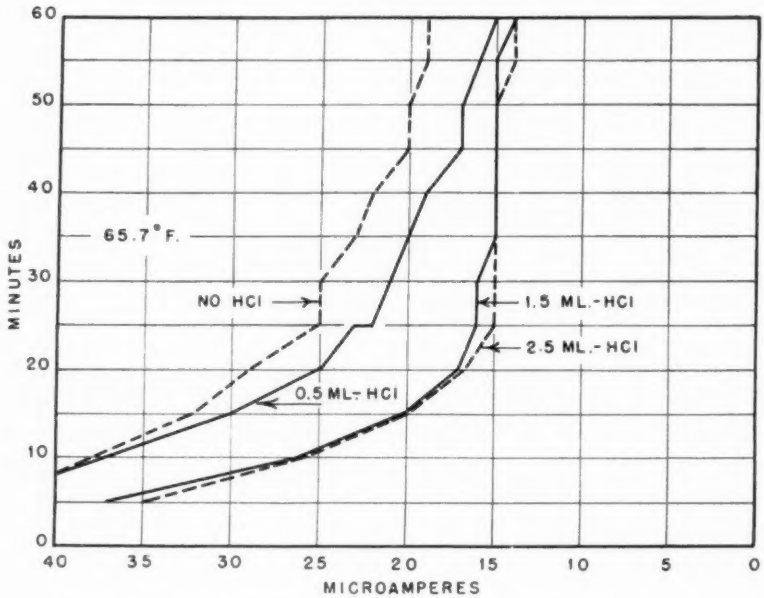

FIG. 9. Effect of Low pH of Solution of Tap Water; start—36.9°F., finish—65.7°F.

the color, which developed in chlorine solutions containing the same concentrations of chlorine, had the same hue and intensity of ortho-tolidine yellow, but that the reaction time for chloramine is longer than for chlorine as HOCl. They also found that when the pH of the untreated water was 7.0 and the contact time for the formation of chloramine was only 15 min., the maximum time for obtaining maximum ortho-tolidine yellow was 15 min., but when the chlorine and ammonia time of contact was 60 min., the maximum ortho-tolidine yellow color developed in 5 min. When the chlorine and ammonia

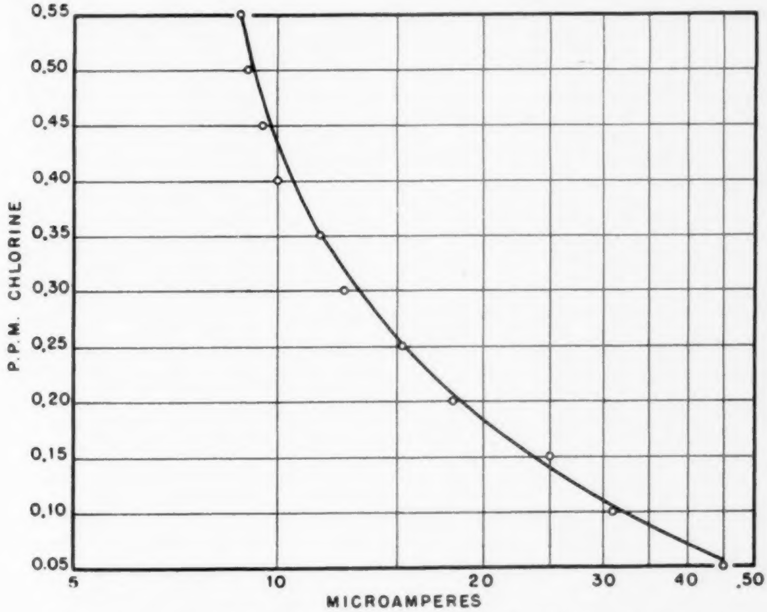

FIG. 10. Calibration Curve for the Photo-Electric Colorimeter

reaction took place in water with a pH of 5 for a period of 15 min., the maximum ortho-tolidine yellow developed in 12 min.; but where the contact time for the formation of chloramine was 45 min. the maximum ortho-tolidine yellow developed in 8 min. They do not give the temperatures of the solutions, but it is supposed that they took place at room temperatures (70°F.).

At Racine, the water used in obtaining experimental curves was treated with anhydrous ammonia and chlorine and the contact time was greater than 8 hr. The results of Adams and Buswell as well as of McCrumb were substantiated in these experiments.

Calibration of Colorimeter

A set of permanent standards was prepared according to *Standard Methods* (p. 21). Dilutions were made from a prepared solution of chlorine, matched with the dichromate standards, then read in the photo-electric colorimeter. A curve was plotted using the dichromate and the microampere readings. Another curve was made using chlorine standards prepared from a standardized chlorine solution and zero water. These were read in the colorimeter and the reading plotted against the concentration of chlorine. This curve and the curve using dichromate standards for determining the parts per million of chlorine were nearly parallel. The variation for high concentrations of chlorine was 0.025 p.p.m. and for low concentrations 0.05 p.p.m.

Figure 10 is the calibration curve for the instrument using standard chlorine solutions prepared from a stock solution of known concentration.

It should be evident from this discussion that the photo-electric cell colorimeter offers certain very definite advantages. Regardless of make, it will give more accurate results in that it will eliminate the human element and in that its simplicity of operation tends toward greater accuracy. Then, too, it obviates the necessity for constant replacement of standards, as a single calibration for any solution holds indefinitely.

Protective Lighting of Water Works

By Robert J. Swackhamer

OFFICIALS of municipally owned public services, such as water systems, should not overlook the possibility of intentional damage during the present world-wide emergency. Under cover of darkness or poor lighting, this may be made possible. Privately owned public utilities and industrial plants in many parts of the United States are recognizing this danger, and are providing protective lighting systems along with other safeguards.

Plans to construct fences and floodlighting systems around all city water, light and power properties as guards against possible sabotage were announced recently in the trade press by Willis J. Spaulding, Commissioner of the Springfield, Ill., plants; and another story from Milwaukee, Wis., indicates that night lighting to prevent sabotage is being installed around the city water plant there. Schenectady, N. Y., has provided protective lighting for its water pumping station and its reservoir will soon be equipped with lighting designed to prevent possible night sabotage.

Although each case usually needs individual attention before specific recommendations can be made, a few general rules on the use of protective lighting may be given, as follows:

1. It is advisable to plan protective lighting for the worst possible visibility conditions so that it will be adequate when sabotage is most likely to be attempted.

2. Protective lighting should be of definite advantage to the property and of disadvantage to the saboteur. If there is any glare in the lighting system, it should be designed to blind the intruder and not the guards.

A paper presented on March 28, 1941, at the New York Section Meeting, Syracuse, N. Y., by Robert J. Swackhamer, Illuminating Engineering Laboratory, General Electric Co., Schenectady, N. Y.

3. Care should be taken not to create shadowed areas in an attempt to illuminate other areas.

4. Light in the foreground of an area reduces distant vision because of contrast. More light around the boundary of a property, or at distant points, is required if the guards are located in well-lighted areas.

5. All backgrounds should be kept as light as possible, e.g. by painting fences and buildings in light colors.

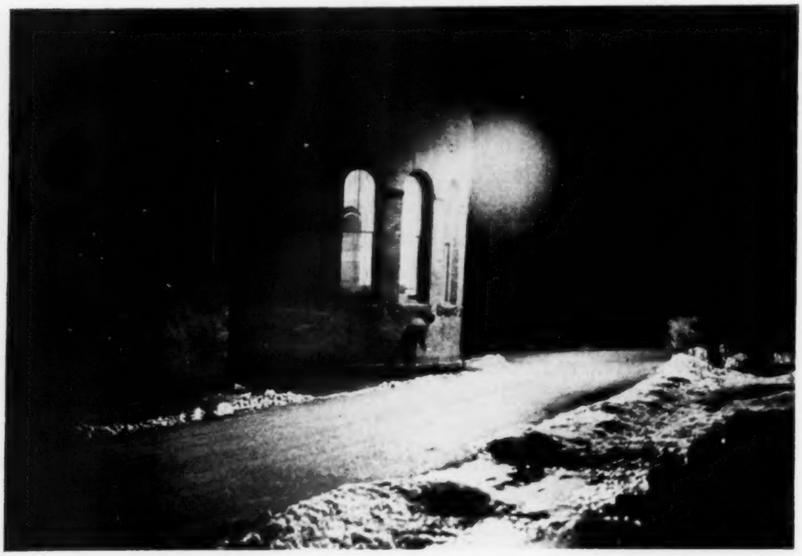

FIG. 1. Example of Proper Lighting; showing disclosure of trespasser

6. Area lighting should be planned so that some light is contributed to any point from more than one source. Thus, a lamp failure will not set up an unduly dark or shadowed area.

7. Lighting along highways, streets, railroads and navigable waterways should be designed so that glare or brightness will not prove a hazard to traffic. The light should be directed across the traffic lanes or at angles which will not be annoying.

8. As much of the lighting equipment as possible should be kept well within the property to frustrate attempts to put it out of operation.

Amount of Light

Regardless of the size and arrangement of the plant or property, the lighting facilities should make it possible for those in charge of the property to detect suspicious characters approaching the fences, attempting to gain entrance, or actually trespassing on the property (Fig. 1); and, as mentioned in Rule 1, protective lighting should be adequate for poor visibility conditions such as heavy night haze,

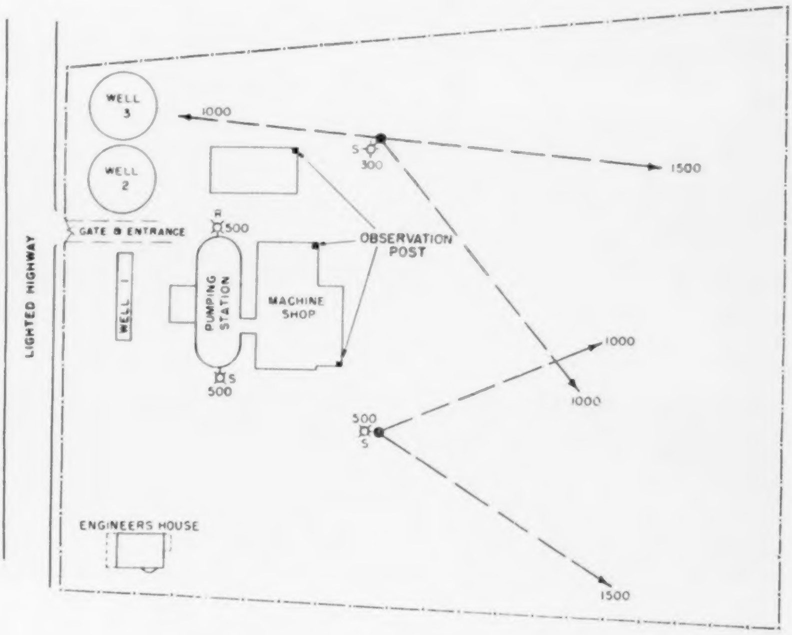

FIG. 2. Protective Lighting System for Small Plants

rain, snow or smoky atmosphere, when the troublemaker would consider conditions favorable for his work.

Experience indicates that an average of from $\frac{1}{2}$ to 1 foot-candle of light should be provided for good night visibility. For example, lighting the boundary fence of a municipal plant with recommended modern pendent street luminaires would require the use of from 2 to 4 watts per linear foot of fence. If floodlighting of the fence or boundary line is desired, from $2\frac{1}{2}$ to 5 watts per linear foot of fence will be adequate with modern medium to narrow beam floodlights,

FIG. 3. Blanket of Light Created by Floodlights

FIG. 4. Illumination of Roadway and Between Important Buildings

using 1,000 or 1,500-watt general service lamps. In lighting the general plant area with recommended wide-beam floodlights, from .06 to .15 watts per square foot of area involved should be used.

For plants small in area, one of the best methods of lighting is to place at advantageous locations, two or three poles equipped with floodlights (25 to 30 ft. above the ground) which are directed toward the buildings and property lines as illustrated in Fig. 2.

In many cases, such as the typical installation referred to, it may be practicable to lay down a blanket of light over the less important areas through which any intruder must necessarily pass in approaching vital points. Under these conditions watchmen are provided

FIG. 5. Fence Lighting System in Operation

with best possible visibility, as illustrated in Fig. 3. If the entire area is occupied by vulnerable materials or buildings, the entire boundary line should be illuminated as outlined later in this discussion.

If the municipal plant property is near residences, floodlighting sometimes proves annoying to the nearby home owners. Note in Fig. 2 that floodlights are not directed toward the "engineer's house," but rather that area is illuminated by pendent street luminaires, one installed on the side of the pumping station and another installed on the nearby pole which supports the floodlights used for illuminating the area behind the plant buildings. Note also the pendent street

luminaire installed on the opposite side of the pumping station to light the area between the two buildings, and also to provide illumination for the roadway, as shown in Fig. 4.

In the larger municipal plants, the fence or boundary lines surrounding the property should usually be lighted as a separate unit. In some instances this may satisfactorily meet all requirements, as where the entire property is under continual surveillance by guards.

The fence can be properly illuminated either with pendent street luminaires or medium-beam floodlights. A fence line application of luminaires was made recently by a large eastern plant. In this installation the units, using 500-watt lamps, were mounted 25 ft.

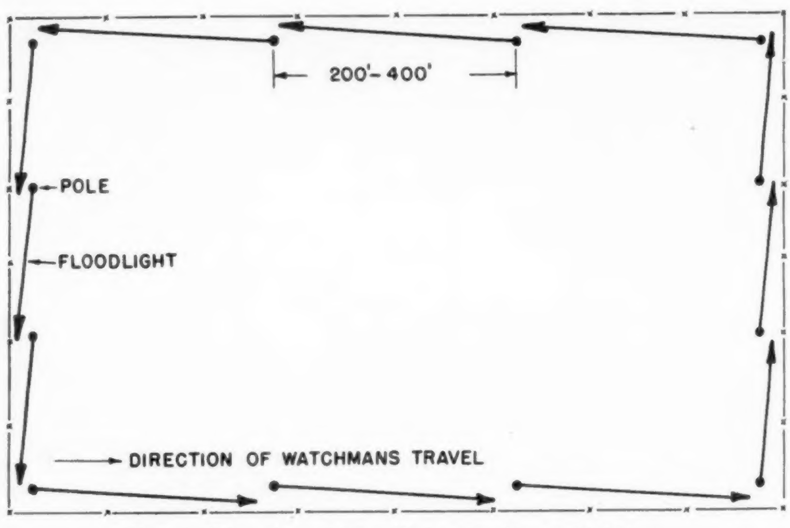

Fig. 6. Direction of Floodlights for Fence Lighting

above the ground. Poles were spaced 125 to 150 ft. apart and set from 10 to 15 ft. inside the fence to prevent tampering from without. The lighting of this fence is shown in Fig. 5.

Constant current series circuits employing 6.6- or 20-ampere series lamps are also extensively used. The choice of electric service usually depends upon the linear distance of fence to be illuminated. Long runs favor the series circuit application. Two series circuit loops, each picking up alternate units, have also been used as an added precaution against failures. Similarly, multiple loop circuits are recommended so that an interruption in the circuit will not cause outages.

When pendent street luminaires are used for fence lighting, an enclosed type unit with a shielded light source and refractor globe is preferred. This makes possible accurate control of the light, and provides an asymmetric distribution of light which will intensify the illumination along the fence line where it is needed most. The shielded light source keeps direct glare of the lamp from the eyes of patrolmen.

Medium beam floodlights can be used in a fence lighting system. This type of lighting is not as effective as that produced by the

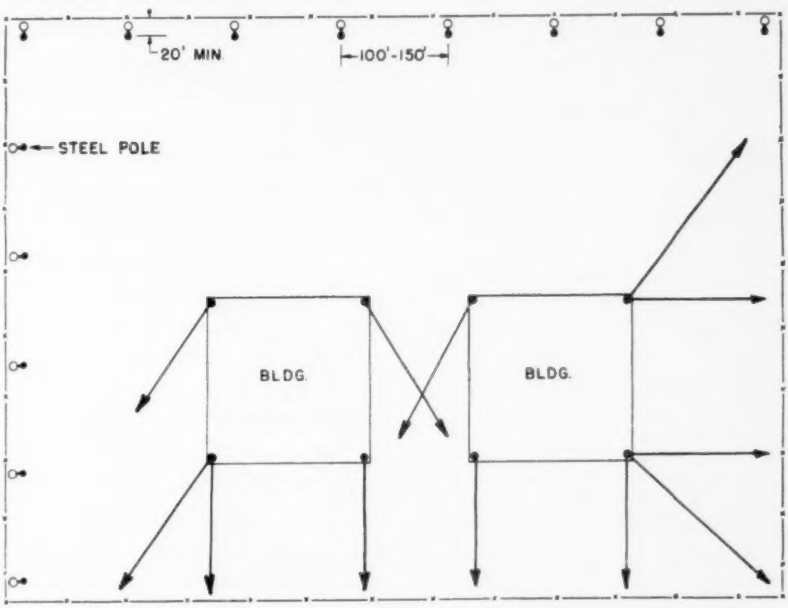

FIG. 7. Proper Installation of Floodlights on Buildings; showing direction of beams

pendent lights but is less expensive. The floodlights can be mounted in pairs and aimed in opposite directions along the fence line. They should be mounted at a height of at least 35 or 40 ft. With the long throw of this projected light it is possible to space poles from 300 to 400 ft. apart. If the property line is patrolled in one direction, a pole spacing of 300 ft. with floodlights directed in the same direction as the guard patrols will prove a better solution (Fig. 6). In either case the guard should keep out of the lighted areas so that he will be concealed from view.

Area Lighting

If the buildings to be protected are located side by side, and are high enough (25 to 30 ft.), floodlights or pendent street luminaires may be mounted on the sides of these buildings, or on the roof edges, directing the light into the area. Among other things, Fig. 7 illustrates this type of installation, where two floodlights are directed between adjacent buildings in such a manner as to eliminate objectionable shadows. Wide-beam floodlights should be used so that their beams will overlap and provide a more uniform distribution of light.

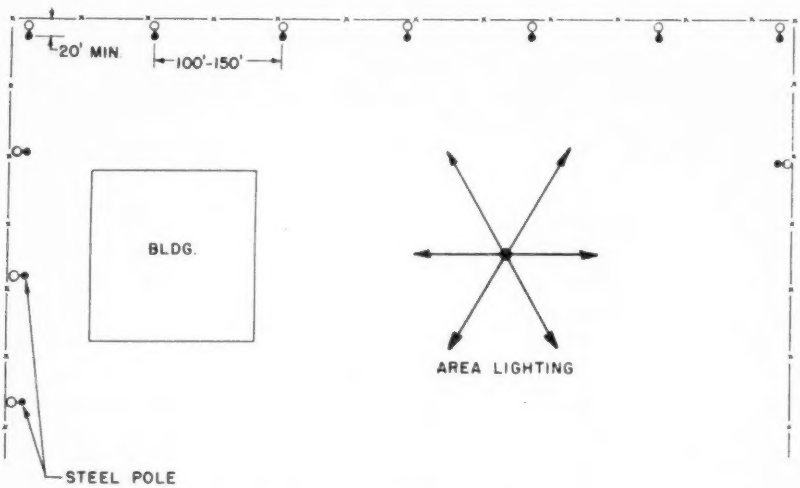

FIG. 8. Area Lighting System

In cases where buildings are not high enough or are erected far apart, or where there is undeveloped plant area adjoining, a system of area lighting should be employed. Steel or wood poles placed in the area, and supporting sufficient floodlights to illuminate the grounds and buildings completely (Fig. 8), will prove effective. Floodlights in such a system should be mounted from 50 to 70 ft. high. As the size of the area increases, the number of floodlights, and their mounting height should also be increased. Wide-beam floodlights can be used in smaller areas where it is not necessary to project the light for great distances. For the larger areas, medium beam floodlights with comparatively high candlepower are recommended.

Area lighting around almost every plant serves added purposes in speeding up night handling of materials and affording safety to the workers.

An additional method of protective lighting, involving the use of searchlights, can also be used effectively in the protection of larger municipal plants. Their use should be looked upon as a supplement to fence and area lighting and should not be depended upon to furnish a complete protective lighting system. Mounted atop guard houses, or at other strategic elevated locations, the mobility and candlepower of these searchlights will make them a valuable safeguard. They can be used to "sweep" the plant area with light at regular intervals or when the occasion demands. They can also "explore" the grounds outside the plant at night at the slightest suspicion of trouble. Eighteen-inch incandescent searchlights with pilot-house control and 1,000 and 1,500-watt lamps are being used for this supplementary lighting.

Auxiliary Supply in Westchester County, N. Y.

By W. E. Thrasher

IN THESE days when the Congress has voted billions of dollars for national defense and when the manufacturing facilities of the nation are being herded and reinforced to produce immediately the equipment required for this purpose, the attention of water works officials is repeatedly drawn to the necessity of preparedness in water works facilities to meet both the present situation and the situation that would result if this country were to be drawn into the war. In the opinion of the writer, the water supply of a municipality is so vital to the welfare of the community it serves, both from the viewpoint of the health of its citizens and industrially, that most of the phases which must be emphasized under the name of preparedness, with the possible exception of a military guard, are essential to a water works under its normal conditions of operation.

There must be no failure of the source of supply, of power, or of distribution facilities which will affect a major portion of the district served, or which cannot be repaired with celerity, and the materials required to make these repairs must be readily available. The sources of supply must be plural, that is, if a system has a single individual source of supply, there should be connections to adjoining systems or secondary sources to the full capacity of the regular source. The plants must have duplicate sources of power or auxiliary generation facilities of ample capacity. The distribution systems must be so looped and crossed that in the event that a portion of the loop should go out of service, there would still be ample water flowing to take care of the needs of the system.

When the writer came to the Westchester Joint Water Works No. 1, he found the supply confined to one source for the major portion of

A paper presented on December 27, 1940, at the New York Section Meeting, New York City, by W. E. Thrasher, General Superintendent, Westchester Joint Water Works No. 1, Mamaroneck, N. Y.

the system. It was possible to obtain a supply for a very small portion of the district from an adjacent community, but this was the only safety factor that existed. The main plant generated its own power by diesel engines and had one circuit from the local lighting company, capable of operating one high lift pump only. There were two units to the generating station, but, during peak periods of the day in the summertime, it was necessary to use both these units. The failure of either one would have meant, under such circumstances, a limitation of the quantity of water which could be consumed or which would be available to combat fires. The financial situation was such that capital outlay for any additional power unit or another source of supply was impossible.

Measures to Secure Standby Equipment

This situation was met by obtaining from the power company, an off-peak rate of purchased power, and facilities were installed, at the expense of the power company, principally, to provide duplicate circuits and transformer capacity sufficient to operate the plant at capacity load. Fortunately, the peak load of the lighting company occurred during the winter, at the time of minimum demand for water service. Although in some respects, this might have seemed a step backwards, it involved no capital outlay, and the cost of power based on the off-peak rate was very little, if any, greater than the cost of generation by diesels. There still remained, however, the one source of supply, depending entirely on one treatment and pumping plant. The distribution system, however, had been looped, with the exception of one or two links, the construction of which had been deferred until the financial situation improved.

In 1935, the Federal Government, through the Public Works Administration, offered grants to the extent of 45 per cent of the cost of such work, and with this offer, too, came the opportunity of acquiring an additional source of supply. Accordingly, the writer was commissioned to study the various possible schemes of supplementing the supply, and to prepare estimates of cost and possible revenue to be obtained through such sources. The most advantageous scheme was decided upon, the authorities of the municipalities informed and brought together, the financial apportionment decided upon, and the writer was given the task of detailing the scheme.

The design was completed, application made for Federal grant, and accepted, and the work begun in 1937. Such a procession of

events may sound simple enough to effect, but with respect to the water works involved, organization was such that considerable time and effort and a great deal of "midnight oil" were required to achieve the result.

The Westchester Joint Water Works No. 1 is owned jointly by three separate municipalities, its board of trustees consisting of the presiding officials of the boards of trustees of the three municipalities. It was necessary first to present the scheme to this joint board and then for the individual members to present it before their respective boards, and for all to agree on the apportionment of the cost between the three communities, each to issue bonds in the agreed amounts. One can imagine the multitude of different forms in which the figures had to be presented to the different boards, so that all of them could be thoroughly acquainted with all phases of the situation.

Design of Auxiliary Supply

The scheme finally decided upon, was to make a connection to the New York City source of supply at the nearest available point. This plan, it was felt, would cause the least expenditure and obtain the greatest additional revenue. The point selected for connection was at the Kensico Reservoir of the Catskill system. The design involved the construction of a pumping station on the shore of Rye Lake, a portion of the reservoir; a pipe line approximately five miles long; a reservoir at the highest point in the system; a standpipe; and facilities for equalization of pressures within the older system. It is necessary to pump against approximately 100 ft. of head in order to top the divide between the Bronx River Valley and the Mamaroneck River Valley, in which the Westchester Joint Water Works system lies. A gravity line would have been possible if tunneling were used, but the size of pipe required and the expense of tunnel construction would have created a greater construction and maintenance cost than the cost of construction of the pump station and the cost of power and maintenance required annually by such a station.

The design of the entire scheme was directed primarily at a system which would require the least possible operating effort upon completion. This requirement was imposed because of the limited number of employees permitted under budget requirements. Toward this end the pumping station was designed to operate automatically and the controls on the pipe line were designed to answer directly to draft

conditions. As will be explained, it was necessary later to modify these controls somewhat.

Pumping Station

The pumping station was to be built in a residential district of the highest possible type, so an architect was commissioned to provide an exterior that would harmonize with its locale. The building (Fig. 1) was modeled along 16th Century English architectural lines, faced with native stone layed in uncoursed masonry, with

FIG. 1. Pumping Station; designed for residential district

varying colors of stone admirably distributed over the surface. Windows and door trim are of artificial stone. The roof is of heavy slate, with an exposure broad at the eaves and gradually lessened to the ridges. The roof is roughened by the installation of pieces of lath at occasional points to give it a slightly wavy appearance.

Within the pumping station, however, the equipment is thoroughly modern (Fig. 2). Facilities for pH control are provided by duplicate dry feeders, dust proofed and equipped with hoppers. Leading through the ceiling to the upper floor, and over the top of the hoppers on the upper floor, a metal enclosure with an exhaust fan leading to

a chimney flue is provided. The feeders are operated automatically by connection to the Venturi meter on the discharge side of the pumps. Duplicate automatic chlorinators are provided in a separate room, and one ammoniator was installed, both types of equipment being operated from the Venturi meter.

There are three electrically-driven centrifugal pumps, two of which may be operated by gasoline engines directly connected to the pumps on the side opposite the electric motor. The operation of the pumps by gasoline engine is manual, but electrical operation is completely automatic. Two of the pumps are of $2\frac{1}{2}$-m.g.d. and the third of

Fig. 2. Interior View of Pumping Station; showing control board

$4\frac{1}{2}$-m.g.d. capacity; and are so arranged that one of the smaller pumps commences the operation cycle. If the small pump fails to meet the demand, the larger unit comes into service and the smaller cuts out, and if this too cannot meet the demand, the smaller pump comes back into service in addition. The other small unit acts as a spare. The one small unit and the large unit may be switched to the gasoline-engine drive merely by tightening a collar coupling and loosening that of the motor. In operation, the engine of the smaller pump is left connected and the other smaller unit left in the automatic electric cycle of operation.

Storage Tanks and Pipe Line

A reservoir concealed underground, consisting of two units, is located at the high point on the pipe line, and the pumps are operated by pressure control in accordance with its water level. All of the electric and control apparatus is mounted in cubicle panels placed side by side and the hydraulic control is in a similar adjacent cubicle. These cubicles are so located as to be accessible front and rear.

The pipe line leading from the plant is 20 in. in diameter, extending through territory not previously served, for 3½ mi. to the new standpipe and from that point on is 24 in. in diameter for approximately 1½ mi., connecting with the existing system at the point of intersection of three 16-inch pipe lines, at one end of the loop transmission system. The line is cast iron, with a coal-tar enamel lining. Approximately ¾ mi. from the pumping station, it passes over the highest point in its travel, and opposite this point are located two metal-lined concrete reservoirs, each 43 ft. in diameter and approximately 20 ft. deep. A valve chamber, on the outside, permits the use of these reservoirs independently or together. The metal lining of these tanks is also coated with coal-tar enamel.

No figures regarding the frictional resistance of this pipe line to the passage of water have as yet been obtained, but the effectiveness of the lining is demonstrated by the fact that the difference between the static pressure at the plant and the pressure with the pumps in operation, is hardly measurable on the altitude gages. In fact, in this respect, the only real "bug," for which it was necessary to apply corrective measures, in the entire original design was experienced. It was found that the pumps were operating against a head so much less than was anticipated that the surge of water in the pipe line, at the time of automatic shut-off of pumps, was far greater than there had been any reason to expect. To correct this difficulty, it was necessary to install a pneumatic tank to overcome the surge.

Standpipe

As originally designed, the standpipe was to perform a double function. The surface elevation of the reservoir is 467 ft. above sea level, and the elevation of over-flow of the elevated tank on the old system is 310. The location decided upon for the new standpipe made possible its use in balancing the effect of the original elevated tank at the opposite end of the distribution system. In the original design, the standpipe was to have been built approximately 40 ft.

higher than the old tank and a control so arranged that incoming water from the new system would rise to any such a point in the standpipe as was required to overcome the frictional resistance of the existing pipe lines, to provide the normal pressure in the older system. The loop of the old transmission system, to which the pipe line from the new pump station was connected, had been only partially completed and a section of approximately two miles of 16-inch main, between the point of connection and the principal points of distribution to the balance of the system, had to carry the major quantity of water served from the new source of supply.

It was to overcome this bottle neck, the effect of which would vary with the draft, that made desirable the freedom of rise and fall in the standpipe. In this respect, however, opposition developed among the citizens who resided in the immediate vicinity of the new standpipe. They took the matter to court, basing their objection on the grounds that any such construction was a violation of the zoning ordinances of the municipality. The case was tried in Westchester County Supreme Court and decided in favor of the water works, but due to the fact that delay might possibly effect a recision of the federal grant, provided the litigants carried the case to the Court of Appeals, a compromise was effected whereby the standpipe was constructed to such a height that the point of overflow elevation was 310. Thus the standpipe became, in effect, a balancing agent to the old elevated tank at the opposite end of the system, and the control of the pressures and flow of water from the new source of supply was effected by the use of pressure reducing valves installed at several points. When these valves are in control, the standpipe must be closed shut out of the system. The operation of these valves requires the exercise of considerable care and caution in the shift from one source of supply to the other, as is necessary upon a number of occasions during the dry periods of summer, and requires the use of several men in the field at the time, with the attendant difficulty of co-ordinating their work. Under the original design, the entire operation of shifting over would have been accomplished by the manipulation of one valve, further operation being completely automatic.

In the design of the standpipe itself, the services of an architect were obtained, and, at a small additional expense, a very pleasing exterior appearance was achieved. (Fig. 3.) The tank is of welded

construction with a hemispherical dome top, over part of which ornamental work has been erected to create the appearance of several steps from the actual dome to the vertical walls of the tank. Just below the last of these steps a series of horizontal bands encircle the tower and join into the vertical pilasters which extend to the base of the tank, thickening gradually as they approach the bottom and there extending outward to the ground to give the appearance of buttresses. In the construction of the tank, eight plates were used

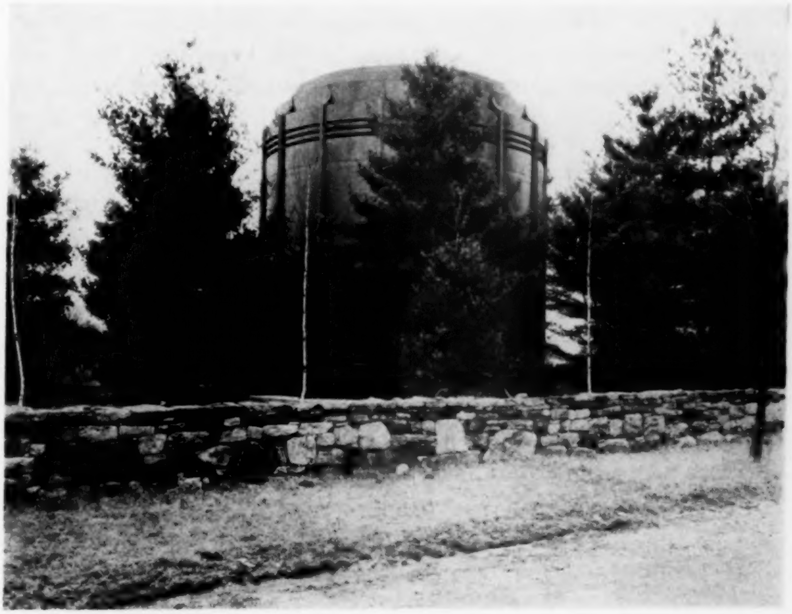

FIG. 3. New Standpipe: screened by tree planting

in each successive horizontal ring. The vertical joints were staggered and the 16 pilasters so placed as to cover all vertical joints in the plates.

The standpipe is partially screened by effective tree planting; and the extra material, provided to meet the requirements of the original design, was utilized to line the concrete reservoirs. Design and construction of the entire system were supervised by the writer and James Hannan, Jr., his principal assistant. Work was completed in the latter part of 1938.

The staff is now engaged in completing that portion of the 16-inch loop on the old transmission system which had previously been deferred under the P. W. A. project. At the completion of this work, it is expected that the shift-over operation between systems will be accomplished with much greater ease and that one or more sets of reducing valves may be eliminated. Furthermore, much greater confidence in the supply has already accrued from the knowledge that a duplicate source of supply exists, that each source is of ample capacity to satisfy the requirements of the territory for some years to come, and that either source can be served through more than one system of piping, or in the event of extreme emergency that both plants may be put in operation serving the whole territory jointly or portions of it individually.

Defense Measures for New York Supply

By Tobias Hochlerner

IT SHOULD first be stated that the views and opinions hereinafter outlined on this subject are not presented by the writer as being official nor as having already been adopted by the Department of Water Supply, Gas and Electricity as part of a definite program for the protection and maintenance of the water supply under war conditions. The problems involved in this matter for New York City are so vast in scope and of such varied nature that the Department has not even begun to formulate such a definite program, although certain steps for the protection of the system have already been taken, as hereinafter described.

It need hardly be stated here that during time of war it is particularly important to maintain an adequate water supply to fight fires, as well as for domestic, industrial and sanitary needs. The general measures to be taken toward this end, as herein discussed, are those which would suggest themselves to every engineer engaged in the maintenance and operation of a water system, and are applicable to, and may be adopted by, cities other than New York City, although possibly on a smaller scale. With the exception of large scale filtration works, there is included in the New York system every structure and facility existing anywhere for the collection, storage, transportation, treatment and distribution of water for the needs of domestic service and fire protection. Although the general features of this system are probably known to most engineers, it might be well, here, to present a brief description of its characteristics as a basis for a clearer understanding of the particular problems involved.

A paper presented on December 27, 1941, at the New York Section Meeting, New York City, by Tobias Hochlerner, Division Engineer, Department of Water Supply, Gas and Electricity, New York City.

New York City Water System

The consumption of water in New York, furnished by the municipal system, is now about 880 m.g.d., but it has been as high as 963 m.g.d in recent years. A brief description of the existing sources and works furnishing this supply is as follows:

1. Catskill Works: The developed Catskill watersheds comprise that of Esopus Creek, having an area of 257 sq.mi. and that of Schoharie Creek, with an area of 314 sq.mi. The Ashokan Reservoir, impounded by the Olive Bridge Dam constructed across Esopus Creek, provides a storage, with flash boards, of 130,428 mil.gal.; and the Schoharie Reservoir, formed by the Gilboa Dam, contains, when full, 19,583 mil.gal. The Shandaken Tunnel conveys the flow from Gilboa and the yield of the Schoharie into the Ashokan Reservoir.

The Catskill Aqueduct is 92 mi. long, extending from Ashokan Reservoir to Kensico Reservoir and thence to the distributing reservoir at Hillview in Yonkers, just north of the city line. Kensico Reservoir, in Westchester County, about 20 mi. north of the city limits, has a capacity of 30,573 mil.gal. and was designed to provide emergency storage sufficient for the city's needs for about 60 days, in the event of an interruption in the flow in the 75 mi. of the Catskill Aqueduct, north of Kensico. This aqueduct has a capacity of about 620 m.g.d., north of, and 750 m.g.d., south of Kensico Reservoir.

Distribution of Catskill water within the city is effected by two deep pressure tunnels extending from Hillview Reservoir. City Tunnel No. 1 extends through the westerly part of the Bronx and across Manhattan to two terminal shafts in Brooklyn located at Schermerhorn St. and Third Ave. and in Fort Greene Park, respectively. City Tunnel No. 2 extends through the easterly Bronx and Long Island City to a connection with the two terminal shafts of Tunnel No. 1, with a branch to a shaft at Hamilton Ave., Brooklyn.

Uptake shafts placed at intervals on both tunnels provide means of making connections to distributing trunk mains, along their route. Large steel conduits connecting to terminal shafts in Brooklyn distribute Catskill water in that borough, and in Queens and Richmond, the latter being supplied by two pipes laid across the Narrows.

2. Croton Works: The Croton watershed comprises an area of 375 sq.mi. lying in Westchester and Putnam Counties, tributary to the Croton River, and its three main branches, known as the Middle,

East and West Branch, respectively. In this watershed there are twelve artificial impounding reservoirs and six controlled natural lakes, with a combined storage of 103,100 mil.gal.

Two aqueducts convey the supply from the watershed, both starting at the New Croton Reservoir, the lowest and largest of the impounding basins. These are the Old Croton Aqueduct, which because of its age and condition now has a capacity of only about 45 m.g.d., and the New Croton Aqueduct, with a capacity of 285 m.g.d Water from both aqueducts is conveyed to the Jerome Park distributing reservoir in the Bronx, and thence to the terminal gate house at 135th St. and Amsterdam Ave., Manhattan. From this point, distribution is effected by means of a number of large pipe lines, several of which convey the water to the equalizing reservoir in Central Park.

3. Watersheds of the Bronx and Byram Rivers: These watersheds, which have a combined area of 22 sq.mi. north of Kensico Dam, are now, in effect, a part of the Catskill system, since their runoff enters Kensico Reservoir.

The Kensico Dam was constructed immediately below a small dam which originally was built across the Bronx River at this location, and the smaller reservoir was absorbed within the large basin now impounded by the New Kensico Dam.

An old 48-inch pipe line constructed to convey water from Kensico is still in service, although its use is now largely confined to several outside communities connected to it.

4. The Ridgewood System: This system, located in Queens and Nassau Counties, extends along the south shore of Long Island from Brooklyn to the Suffolk County line and furnishes water from 22 plants pumping from wells, infiltration galleries and ponds.

The transportation system consists of a masonry aqueduct and a 72-inch steel conduit, both of which extend from Ridgewood Pumping Station to the Suffolk County line, and two cast-iron pipe lines from Milburn to Ridgewood.

5. Brooklyn Borough: The Brooklyn system constitutes well pumping plants located in Canarsie, New Lots and Gravesend.

6. Queens Borough: The Queen system is made up of well pumping plants located in Douglaston, Flushing, Forest Hills and Rockaway Park.

7. Richmond Borough: The Richmond system is made up of well pumping plants located in Grant City and Bull's Head.

Adequacy of Supplies

The safe or dependable supply of these sources, i.e. the quantity that can be drawn therefrom continuously over a period including the driest on record and with storage in impounding reservoirs drawn down only 75 per cent is assumed to be as follows:

	m.g.d.
Catskill, including Bronx and Byram	525
Croton	310
Long Island, including Queens and Brooklyn borough plants	135
Richmond well plants	10
Total	980

With normal rainfall and runoff, the Catskill and Croton sources are drawn upon up to the capacity of the aqueducts, the Long Island and Richmond well plants being used only to supplement these gravity sources, as the wells are the most expensive to operate.

Catskill water reaches the city at an elevation of 295 ft. and practically all of it can be distributed by gravity, while the Croton gradient at the 135th St. Gate House is at elevation 125, so that only one-third of the water from this source can be so distributed, the remainder being pumped at several plants in the Bronx and Manhattan. The extent of such pumping is only that required to supplement the Catskill supply.

Certain sections, notably the Washington Heights district in upper Manhattan and small areas in the other boroughs, however, are at too high an elevation to be served even by the Catskill gradient, and pumping plants must be operated continuously to supply such areas.

Mention should also be made of an electrically operated pumping plant installed in the Croton Lake Gate House, having a capacity of 180 m.g.d. This station pumps from the Croton Reservoir into the adjacent Catskill Aqueduct and is operated intermittently to equalize the storage between the two watersheds, so that the Croton Reservoir can be utilized to fuller advantage.

Since the demand for water has about reached the dependable supply of existing sources, the City has under active construction a project to secure an additional supply of 540 m.g.d. from the watersheds of upper Rondout Creek, the East Branch of the Delaware River and Neversink River.

The Delaware Aqueduct, a deep pressure tunnel about 85 mi. in

length, will convey this water from an impounding reservoir, being constructed on the Rondout Creek, to the West Branch Reservoir of the Croton system and thence to Kensico and Hillview Reservoirs.

The completion of the aqueduct and the delivery of 100 m.g.d. from the Rondout watershed is expected in the summer of 1945, with an additional 70 m.g.d. from the Neversink in 1947, this completing the first stage of the project. The completion date of the second stage which will provide 370 m.g.d. from the East Branch of the Delaware is uncertain, but is now expected to be some time in 1954.

Indicated Protective Procedures

The measures to be taken for the protection of this supply and the maintenance of service in emergencies may be grouped in three general categories:

1. Guarding of all structures to prevent sabotage, and their protection in advance, insofar as this may be possible, from injury or destruction by aerial attack. Also safeguards and protection against willful pollution of the supply.

2. Formulation of a comprehensive plan or program whereby a change in the usual method of operation may be effected quickly and the supply maintained in the event of the failure or destruction of vital parts of the system. This would include the installation of duplicate facilities, to a reasonable extent, for use in emergencies.

3. Organization of an adequate force with provision to make this immediately available, together with the necessary materials and equipment, to effect repairs and replacements in the shortest possible time.

Defense Measures in Practice

In the matter of guarding its system and for sanitary protection of its supply, New York City has already taken the following steps:

1. A force of Board of Water Supply police, on motorcycles, is constantly patrolling the entire periphery of Croton Lake and Kensico Reservoir and the area along the line of the Croton and Catskill aqueducts, particular attention being given to surface structures and sections where the aqueducts are not in tunnel.

2. Department inspectors are patrolling the watersheds in motor cars in areas where fishing and boating will be permitted under re-

vised regulations. Under recent legislation it will be possible to have these employees, numbering about 200, appointed as peace officers with power of arrest, after being sworn in and enrolled by the local sheriffs.

3. Under the provisions of laws previously enacted, the department had issued some 18,000 permits to individuals for fishing and boating on up-state impounding reservoirs, these permits having been granted to all who requested them, without regard to the identity or character of the permit holders. Such a situation which permitted indiscriminate access to water supply lands and reservoirs by a large number of persons, with but minor restrictions, manifestly could not be allowed to continue. The City therefore secured the enactment of legislation, in the face of considerable opposition, which enabled it to rescind all existing permits of this nature. It is now re-issuing new permits only to persons who are citizens of the United States and are otherwise qualified to receive them and whose identity is established by photographs affixed to the permits. Furthermore, fishing and boating are now restricted to certain locations, remote from vital control structures and where a closer watch may be maintained over the permit holders.

It is expected that the number of permits will be substantially reduced by the new regulations, since only about 400 to 500 had been re-issued on applications submitted at the end of 1940.

4. Within city limits police have been stationed at all pumping stations, gate houses and other vital structures and all employees of the department have been furnished with identification cards, including photographs, which must be presented before access is permitted to water supply structures. Access of persons other than employees is afforded only to those presenting special letters of authorization, signed by an administrative officer of the department.

5. Partly as a defense measure, the department is arranging to chlorinate all effluent mains leading from the four open distribution reservoirs within City limits. Although all the water entering these reservoirs has previously been twice chlorinated, it may be subject to secondary pollution from various causes, and possibly by sabotage, so this additional chlorination is considered a necessary safeguard.

6. For the same reasons, the department has arranged to have its laboratory force procure and analyze water samples from all reservoirs at more frequent periods than under normal conditions.

These measures for guarding water supply structures would have

to be enlarged considerably in scope and intensity in the event of actual war. During the World War, patrolling of the reservoirs and aqueducts was carried on intensively not only by Board of Water Supply police and department employees but also by a unit of the National Guard. In addition to the patrol work, fixed posts for continuous guard were established at gatehouses, blow-offs, siphon chambers and all other surface structures on the aqueducts, where men were not continuously in attendance for purposes of operation. No incidents involving sabotage or willful injury to structures are believed to have occurred then.

Vulnerability of Structures

The matter of protection of water supply structures from aerial attack was one which gave little or no concern during the World War, but which is of the utmost importance now. Very little information is available from the present war zones as to the effect of bombing on various kinds of water supply structures. It would seem that vital structures covering a small area, such as shaft chambers and possibly small buildings, could be made bomb-proof by a heavy reinforced concrete protective roofing or possibly even by sand bags placed to advantage.

The dams forming the most important impounding reservoirs in the New York City watersheds are all of the gravity type being constructed of massive masonry or cyclopean concrete, and it is believed that their stability could be endangered, if at all, only by the most severe and concentrated bombing. The sloping downstream faces of these long high dams, however, could present good targets from the air, and it is suggested that their visibility could be greatly reduced by camouflaging such surfaces, either by paint or by the placing of foliage, so that they will blend with the landscape. This planting should, of course, be carried for some distance upstream and along the shores from the dam so that the division line between water and masonry could not easily be discerned from the air. Although masonry dams may not be very vulnerable, it is, however, likely that earth dams may be more easily breeched by bombing.

Where the aqueducts are in tunnel, they would hardly be subject to injury, but the cut and cover sections and the steel pipe siphons crossing valleys are vulnerable points.

The Old Croton Aqueduct is practically all surface construction, but its loss even for a prolonged period would not be serious. The

New Croton Aqueduct is practically all constructed in tunnel, there being only a very short section in cut and cover; but of the total length of 92 miles of the Catskill Aqueduct, 55 miles are of the cut and cover type, and there are six miles of steel pipe siphons. These cut and cover sections have long since become overgrown for the greater part of their length, and their detection from the air would probably be very difficult. The visibility of such sections as are not now naturally protected should be reduced to a minimum by further planting.

In regard to the works within the city limits, the two deep tunnels distributing Catskill water would hardly appear to be subject to damage except possibly at their shafts and chambers. The chambers occupy areas only approximately 20 x 40 ft. and occur at intervals of about 4,000 ft. While the chances of their being struck are not very great, some form of protection would be desirable. It should be stated that these shafts are equipped with riser plug valves which would automatically close if the chambers were flooded, leaving the main tunnels intact.

With regard to the distribution system, there are in service in the city some 4,950 mi. of mains varying from 4 to 72 in. in diameter, of which about 400 mi. are trunk feeders, 30 in. or larger. Of the latter, some 85 mi. are of steel, the department having adopted the policy, since 1926, of laying all large mains with steel pipe. All mains larger than 48 in. are also steel, and these mains would not be as vulnerable to breaks as would cast-iron pipe.

The system is of such strength and so inter-connected that one or even two large feeders could be put out of service temporarily without serious impairment of the supply. In Manhattan, south of 34th St., and in the congested sections of Brooklyn, along the waterfront, there is a separate system of high pressure fire service mains, served in each borough by pumping stations, which normally take suction from fresh water mains, but which can also be served by salt water intakes in emergencies. These special facilities for fire fighting would be supplemented by fire boats along and adjacent to waterfronts.

In the event of war, the breakage or destruction of water mains on a large scale from aerial attack must be anticipated, and the provision for quick repair and replacement of these mains probably presents the most serious problem. When breaks in water mains are accompanied, as is quite probable, by rupture of adjacent sewers there will be the added danger of pollution of the supply.

Program for Emergencies

The preparation of an advance plan for changes in operation and other measures to be taken to maintain an adequate supply to cover all possible contingencies is difficult, if not impossible, for a large water system, and particularly for a system so vast in scope as that supplying New York. In the last analysis, it will be the experienced operator in charge, who is familiar with every detail of his plant, who must make quick decisions, and who must adopt such measures as are called for by the actual conditions which may arise. For smaller systems, deriving their supply by pumping from adjacent streams, it would seem that the principal means of safeguarding the supply would consist in providing adequate reserve pumping equipment and an organization to make quick repairs to water mains. Provision should also be made, where at all possible, for connections to adjacent systems to secure an emergency supply.

In New York City, a general program of procedure has been in existence for many years to take care of what may be called normal conditions, involving interruption of the supply because of breaks or eliminations of important parts of the system. This would have to be revised and enlarged to cope with the more serious eventualities arising under war conditions. The city is fortunate in that its principal supply is furnished by gravity from two up-state watersheds and that these can be supplemented, as required, from local sources. These three systems are all inter-connected, and water from one can be substituted for that normally supplied by the others, so that a complete cessation or even a serious impairment of the supply is hardly possible.

If the entire Croton system were eliminated temporarily, a fairly adequate supply could still be maintained from the Catskill system aided to the fullest extent by the Long Island sources. In the event of a break in the Catskill Aqueduct north of Kensico Reservoir, the storage in the latter, supplemented by the greatest possible use of the Croton and Long Island systems, would maintain the supply for about two months, during which time repairs could be effected. If the break should occur north of the connection to the Croton Lake Pumping Station, the pumpage at this station, 180 m.g.d., could be utilized to lessen the draft on Kensico Reservoir so that the storage therein would be available over a longer period. The most serious situation would be created by a break in the 20 mi. of Catskill Aque-

duct between Kensico and Hillview, leaving only a 48-inch pipe line as a means of conveying Catskill water into the city.

It is fortunate that progress on the construction of the section of the Delaware Aqueduct between Kensico and Hillview is much further advanced than on others, the need for duplication of this vital part of the Catskill Aqueduct having been hitherto fully realized. The completion of this section is expected in about two years, and this will aid, to a very great extent, safeguarding of the supply. When the entire new aqueduct becomes available, in 1944, worries with regard to the transportation system will be over, since the Delaware is a deep pressure tunnel for its entire length. Thus the Delaware development, originally started as a project to augment the city's supply, can now also be considered as a defense measure of the greatest importance in safeguarding this supply.

The organization to be set up to effect speedy repairs to and replacements of water supply structures which may be damaged or destroyed should logically be an expansion of that now existing for the maintenance, operation, and extension of the system, and the work should be carried on under the direction of engineers and superintendents now in charge of these activities. The five boroughs comprising New York City have their own special water supply conditions and problems, and, under the present organization which has been in effect for nearly 30 years, all maintenance, operation and construction work is under the direction of an engineer assigned to each borough. The maintenance and operation of the up-state system is under the direction of a Division Engineer, with headquarters at Kingston, N.Y., whose assistants in immediate charge in the Catskill, Croton and Schoharie watersheds, report to him. All borough and division heads report directly to the Chief Engineer or Deputy Chief Engineer.

For maintenance of the distribution system and the repair of water main breaks, etc., the boroughs are divided into districts, each in charge of a foreman who directs several gangs of workmen. The forces in the various districts operate from Repair Headquarters, which include garages, shops, yards and offices, and all foremen are under the direction of a Superintendent of Maintenance, reporting to the Borough Engineer. There is also a separate gang in Manhattan for the maintenance of the high pressure fire service system, and this gang is also, at times, available for low pressure work.

Personnel and Equipment of Repair Crews

The total force engaged in the maintenance of distribution throughout the City consists of approximately 1,500 men, a number that will manifestly be inadequate to cope with a situation which may bring a large number of simultaneous breaks in mains and damage to other water supply structures. This situation would not occur in all boroughs at the same time, and arrangements should be made for the quick transportation of force and equipment from one borough to another. The organization set up to effect repairs and maintain water supply should work in close co-operation with the other city departments, with provision to draw upon their forces.

In recent practice, almost all water mains of 20-inch and smaller sizes, are being laid by labor provided by the Work Projects Administration. The force engaged on this work consists of approximately 2,000 men, divided into about 50 gangs, operating in all boroughs. This W.P.A. force has its own supervisory personnel, but their work is done under the department's inspection and general supervision. Assuming that permission can be obtained from the Federal authorities to divert this labor temporarily from its usual pipe laying activities there is available in this W.P.A. force a large addition to that now employed by the department, to be impressed into service at short notice on emergency maintenance and repair work. This force could be organized into gangs to work under the department foremen and superintendents, who are familiar with the system and particularly with the location of valves and other appurtenances on the mains.

As to repairs of major or particular nature, such as submarine lines, aqueducts, gatehouses, buildings, etc., which cannot be speedily effected by department or W.P.A. forces because of the need for special equipment and labor, the Commissioner of Water Supply, Gas and Electricity has power, under the law, to declare the existence of an emergency and have the work done immediately by a contractor on a cost-plus basis. It would be desirable to have enrolled a list of such contractors, who have indicated their availability for emergencies of this nature, and who can have an adequate force and equipment on hand to start work on short notice. This list should properly include the organizations now at work on the several contracts with the Board of Water Supply for the construction of the Delaware Aqueduct, who could temporarily divert all or part of their force

and equipment to emergency work in the watersheds and on existing aqueducts.

The motor vehicle equipment, including trucks, compressors, cranes, trench pumps, etc., now utilized by department forces for maintenance work in the city, would be augmented for emergency needs by some 90 pieces of equipment of this type which the City has heretofore purchased and assigned to the W.P.A. for use on the water main installation projects previously mentioned. There will, however, be need for more equipment of the kind enumerated, and particularly for trucks mounting equipment for quick closure of large valves, and for excavating machines of various types.

The stock available in the yards for water main repairs would also have to be greatly increased; and certain special materials to effect quick temporary repairs of this nature should be provided for both the low pressure pipes and the high pressure fire service mains. These materials should include sections of cast-iron and steel pipe, valves of various sizes, and a stock of couplings and facilities for welding steel pipe in the shortest possible time. The quick repair of broken high pressure fire service mains will be particularly important; and it would seem desirable to cut in additional valves on both low and high pressure systems to limit shut-offs.

For rapid repairs to cut and cover aqueduct sections, an adequate stock of lumber and other material must be available at central points for the construction of temporary flumes. Steel pipe sections adapted for welding should also be provided for use on repair of the siphons of this type of aqueduct construction. Finally, provision should be made for portable chlorinating machines, mounted on trucks, for sterilizing mains where pollution may occur or be anticipated because of breakage in sewers adjacent to water mains.

In the case of pumping stations which must be operated continuously to supply certain high areas, it would be desirable to provide duplicate pumping equipment of a temporary nature, preferably installed undergound, for use in the event that the main station is put out of commission. Where these stations are of small capacity, portable gasoline driven pumps should be provided to maintain the supply, or possibly a fire engine could be used temporarily for this purpose, pending repairs.

Health Department Defense Measures in Nassau County, N. Y.

By J. L. Barron

A DISCUSSION of public water supplies and national defense from the point of view of a county health department cannot be as stirring to the imagination as one from a major water department such as New York City with its problems of maintenance and protection of far flung works. To a health authority such as that of Nassau County, where some thirty water systems are supplied by underground sources, the current national defense program and the possible ultimate wartime disruption and sabotage are chiefly an occasion for an intensification of normal supervisory work.

Nassau County is a belt across Long Island from Long Island Sound to the Atlantic Ocean, immediately east of New York City's Borough of Queens. The supply and quality of the County's water have been described by Suter (1), Laase (2), and Norcom (3) in 1938. In population growth in the last decade, Nassau, with a percentage growth of 33.6 per cent, led all other counties within New York State, including metropolitan New York. Long Island as a whole was exceeded in per cent of population growth only by the rest of New York State, Pennsylvania, Illinois, Ohio, California, Texas and Michigan. Obviously the population growth has had its effect on the urgency and nature of the Nassau County Health Department's planning.

Among thirty water supplies, there is a wide diversity in the experience and efficiency of management, in the maintenance of records and essential data, and in the ability to recognize and deal with emergencies. A common health department is the only normal agency which can attempt to co-ordinate such water supplies and direct attention to the elimination of deficiencies. Such a health depart-

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ment, however, can be effective in such an activity only to the extent that it possesses experienced public health engineering personnel.

Survey of Water Supplies

In Nassau County, the health department is engaged in completing an elaborate record for each water system, through conferences with the water supply officials and inspections of the works. This is an essential first step by which to determine the character of personnel in charge, the adequacy of records and the physical status of each supply. The work is revealing superintendents who know their systems thoroughly, who have conscientiously ferreted out cross-connections, and who scrupulously sterilize and check on new mains put into use. Others are found who have little familiarity with their systems or with water works practice, who are vague or unconcerned about cross-connections, and who scoff at the idea of cleaning up new mains or repair jobs.

On the basis of this information, it is possible for the county health department to make and follow up on detailed recommendations to the municipalities, districts, and companies where conditions are not satisfactory. It will be possible to prepare a map showing the location of the numerous connections between these systems and indicating the extent to which the various systems could be supplied in case of local failure. There can be developed a fairly complete picture of the emergency and standby sources, power units and auxiliary equipment available throughout the county. Considerable information can also be compiled as to reserve stocks of pipes, valves, specials, repair equipment and so forth. The health department's major contribution is therefore the assembling of essential information on water supplies in such form that it can be readily used in case of emergency.

Rôle of Health Department in Defense

As a co-ordinating agency the health department has special opportunities and responsibilities not only in relation to other county and municipal departments but also as between water supply agencies. The recent sponsoring of a water superintendents' conference in Nassau County has undoubtedly been a contribution to local defense in that it is providing a means for water supply officials to become better acquainted and to discuss local problems peculiar to the county. The broader comprehension of water supply practice growing out of

such local meetings is of course more fully attained through membership and active participation in the A. W. W. A. The proper use of its JOURNAL by every water superintendent as a source of information and a stimulation to efficient work is to be promoted by every alert health agency.

One of the duties of a health department is to verify, at reasonably frequent intervals, the fact that water supplies used by the public are being delivered without contamination. In some instances, health departments may depend in part on laboratory results provided by the water supply agency. These reports, however, should always be subject to verification in a laboratory immediately responsible to the health authority. Furthermore, in times of emergency, the health department must be in position to determine with the least possible delay the safety of a water supply or the efficacy of disinfecting treatments following any contamination or disruption of service. For these purposes a public health laboratory as a part of the health department is essential.

The lack of such a laboratory in Nassau County is at present engaging the attention of the Nassau County Defense Council, with the probability that the establishment of a laboratory will be recommended as a vital element in the county's preparation for defense. Such a laboratory can function on a twenty-four hour basis in times of emergency, not only on water, milk and food examinations, but also in connection with communicable disease problems affecting military forces and adjacent populations.

Need for Experienced Personnel

Health departments have played an important part in meeting disasters of various kinds in recent years, the effectiveness of this aid being in proportion to the modernness and quality of the particular department in personnel and organization. The Committee on Municipal Public Health Engineering of the American Public Health Association in a report (4) presented in October, 1940, at the A. P. H. A. Detroit meeting, stated that many large municipalities in this country do not yet employ any engineering personnel in the health department, and it points out that the medical health officer is therefore unable to function effectively in the control of major environmental factors including water supply. The suggestion was further made that the United States Public Health Service and other federal departments concerned with training camps and war industry popu-

lations in and adjacent to large municipalities, encourage in a positive way the use of competent public health engineers by such municipalities.

This whole problem may be summed up briefly in the statement that every water department should be managed and operated by trained and experienced personnel and that every department of health should likewise employ men qualified for the duties to be performed. Then, with thorough co-operation based on mutual respect and understanding between such departments, any emergency can be met and surmounted with a minimum of disturbance and hazard to the public being served.

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Algae Control

By William D. Monie

THE Commonwealth Water Co. of Summit, N. J., supplies a population of 160,000 people through three stations, two of which supply 100 per cent well water, and the third, and largest, both well and surface water. The surface water is stored in an artificial reservoir, about 204 acres in area, having an average depth, when full, of 11 ft., and a maximum capacity of 735 mil.gal. The reservoir has no natural inlet, but is filled during rainy weather by pumping water from a nearby brook. Thus, in an average summer, the reservoir constitutes a constantly decreasing body of water entirely exposed to light. As its maximum water depth is only 11 ft., the conditions manifest over its entire area are comparable to those which would be considered the worst problems of a normal reservoir; and since the temperature rises to as high as 80°F., it is clear that the reservoir is a paradise for algae. Such a situation, of course, demands effective methods of control, based on satisfactory methods of analysis; and it is the application of those methods which this paper will describe.

Laboratory analysis is accomplished by the Sedgwick-Rafter method. In preparing samples for examination by this method, 500 ml. of water are filtered through Berkshire sand, and the sand washed with 10 ml. of distilled water, making the degree of concentration 50. A 1-ml. portion of this concentrate is then placed in a rectangular Sedgwick-Rafter cell and examined under a microscope having a magnification of 100 (a 16-mm. objective and a 10x eye piece with a draw tube length of 160 mm.). As no ocular micrometer is furnished, all the counts consist of counting ten entire fields and recording the total number of organisms in each. The counts, there-

A paper presented on February 19, 1941, at the New Jersey Section Meeting, New Brunswick, N. J., by William D. Monie, Chemist, Commonwealth Water Co., Summit, N. J.

fore, are about 15 per cent higher than a count in standard units. For sampling purposes, the reservoir is divided into six sections (Fig. 1), from each of which samples are taken daily during the summer. Counts are made on these samples, and the average of the six is considered the daily count of the reservoir.

Copper sulfate is applied by placing the chemical in burlap bags, and dragging them through the water behind an ordinary flat-bottomed boat propelled by an outboard motor. This treatment requires only two men, one to handle the boat and the other to take care of the bags. Distribution of the chemical is accomplished by the strip method. Starting in Sections 1 and 6, strips, about 30 ft. wide, are taken completely through the reservoir, ending in Sections 3 and 4.

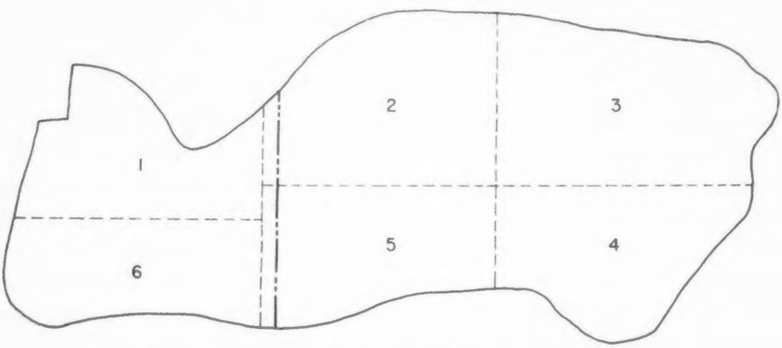

FIG. 1. Reservoir; showing breakdown into sections

The effectiveness of these methods was put to a real test in the dry summer of 1939. The Commonwealth Water Co. was one of the fortunate suppliers which did not have to require its customers to curtail their use of water in any manner. In order to meet the demand, however, it was essential that the reservoir be kept in good condition. Records indicated that the reservoir had been seriously affected by algae trouble each year previous to that time, and it was known that such algal attacks meant that the amount of water which could be filtered without causing taste decreased materially, so it was realized that some effective method to prevent such a decrease in capacity had to be applied.

Conditions during the year are summarized graphically in Fig. 2, the data of which clearly indicate the relationships among the rise and fall of algal population, the reservoir water level and the temperature record.

Surface Elevation and Temperature Data—1939

The elevation of the reservoir is given in feet above sea level. When full, its surface elevation is 179 ft. The average bottom is at an elevation of about 168 ft. Beginning on about the first of May and continuing until the end of September, the elevation took a steady drop, due, of course, to the dry summer which necessitated the constant use of water from the reservoir with no replenishment. The low elevation caused considerable trouble in treating the reservoir after it dropped below 173 ft. When the land was cleared for the reservoir, a number of trees were cut down and the stumps left standing. At a surface elevation of 173 ft. and less, these stumps make uniform treatment of certain areas of the reservoir practically impossible.

It is to be noted that the temperature ranged from 36° to 80°F. *Asterionella* began to appear at a temperature of 36° and remained until it reached 75°, but did not reappear until the temperature again reached 40°, in November. *Mallomonas* started in the cold weather and simmered out at 50° then reappeared at 66° and lasted through temperatures as high as 79°, finally dropping out at about 76°.

Anabaena came in at a temperature of 79°F. and finally dropped out at 69°. *Aphanizomenon* appeared at 72° and did not leave the picture until the temperature dropped to 38°. It was feared that, having such a good start, *Aphanizomenon* would remain for the entire winter, but fortunately this did not occur.

Reservoir records substantiate the fact that usually only one organism is predominant at any one time, although others may be present. It has also been found that in some cases treatment for the predominant organism changes conditions so that one of the other organisms present multiplies quickly to a position of predominance.

Many other species of algae, including *Dinobryon*, *Pandorina*, *Synedra*, *Ulothrix*, *Strauraslrum*, *Scenedesmus*, *Protococcus*, *Pediastrum*, *Cosmarium*, *Certium*, *Botryococcus*, *Melosira*, *Coelastrum*, *Difflugia* and others not in sufficient quantity to count and record, were present, but those given in Fig. 2 are the ones which caused trouble in the reservoir.

Treatment Data—1939

The small treatments for *Asterionella* given on February 27, March 3 and March 4 are interesting to note. The counts of *Asterionella* on those dates were 1,392, 2,340 and 1,924, respectively; so the small

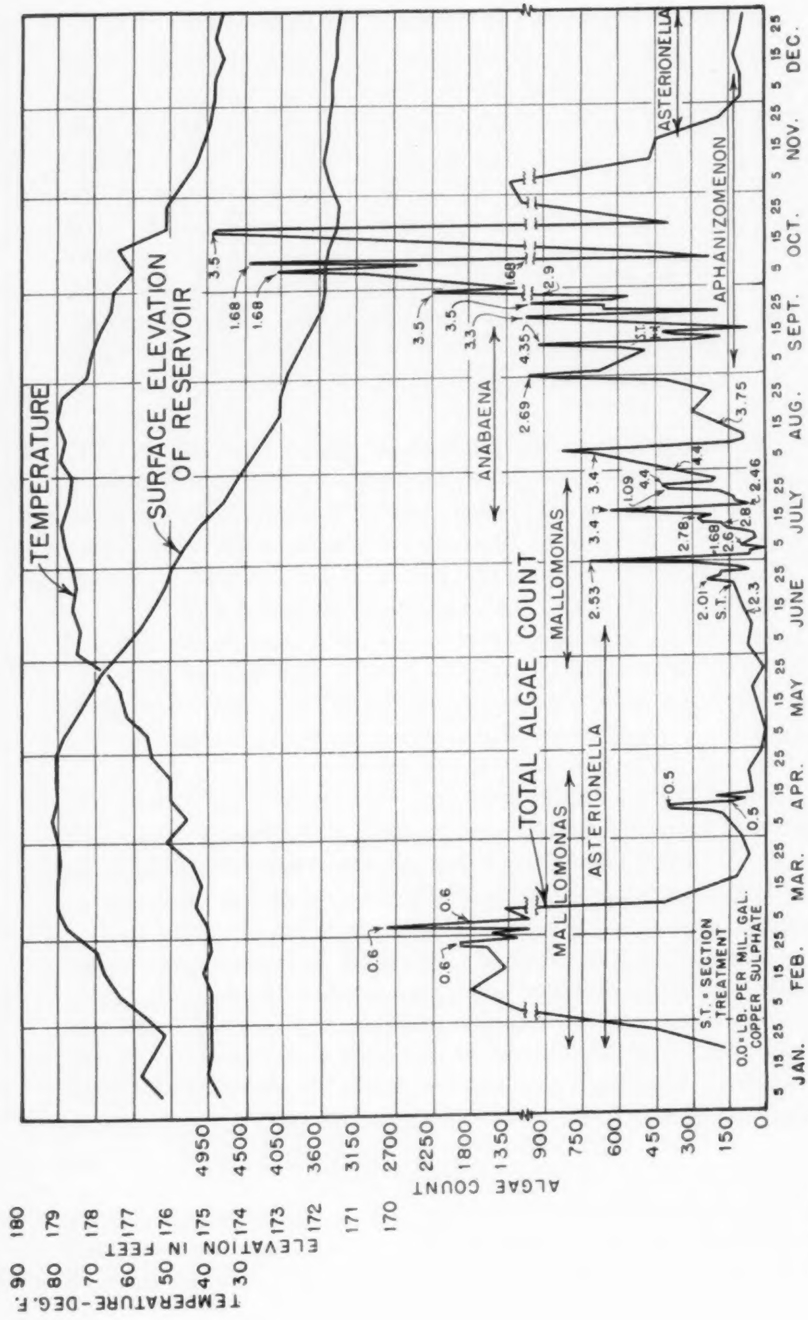

FIG. 2. Reservoir Data for 1939; showing total algae count by weekly average except near treatments, where daily counts are given

NOTE: Author assumed charge of reservoir on May 1.

size of the treatments was dictated by the difficult treatment conditions at that time of the year rather than by the number of algae. It is felt, however, that the drop in count, which followed on March 9, was as much due to the increase in temperature as to the effect of the treatment.

Two further small treatments for *Asterionella* were made on April 12 and 13, when the counts were 380 and 149, respectively. As indicated by the curve, the effect at that time, too, was erratic, the count dropping to about 90, increasing on the next day to about 200, and finally dropping to stay.

The author wishes to digress here to point out that it is his opinion that the fact that these treatments were split, i.e. the dose divided and applied on successive days, did not increase their effectiveness, but, to the contrary, he believes that, to be effective, the entire dose of a treatment must be applied at the same time.

The probable reason for the split treatment procedure in the cases in question was the temperature of the water at the time that dosing became necessary, following from the fact that the solubility of copper sulfate varies directly with the temperature of the water to which it must be applied. It is the consensus of opinion that the colder the water, the more chemical is required to achieve the same effect—an opinion which, no doubt, is based upon the knowledge that water becomes denser as it becomes colder, and that, therefore, diffusion of the chemical must be less.

Beginning on April 15, with the drop in count which followed the second series of treatments, no further algae troubles were experienced throughout the general rise in the temperature of the water, until June, at which time *Mallomonas* began to increase.

In the effort to prevent the trouble before the rise gained momentum, a dose of 2.3 lb. per mil.gal. of copper sulfate was applied on June 12, but the treatment was unsuccessful.

The size of dose in some of the treatments which followed will probably seem unusual, but the realization that the amount of copper sulfate necessary to kill the same organism varies with different waters, will explain their determination. Records were examined and the dose of copper sulfate determined from the amount that seemed to have been effective in the past for the particular organism in question. In addition, inquiries were made among the men at the plant, who had been in contact with the reservoir since its construction, in the effort to benefit from their experience.

On June 24, the first attempt at section treatment was made, when the counts in Sections 1 and 6 were considerably higher than those in the other parts of the reservoir. Copper sulfate was applied only in the two sections affected, but, as is obvious from Fig. 2, the procedure resulted in complete failure.

On June 25, the entire reservoir was treated with a 2.01 lb. per mil.gal. treatment. At that time the count was 244, practically all *Mallomonas*. The count decreased for three days after the dose was applied and then increased so that on the sixth day after treatment, the count, practically all *Mallomonas*, reached 700. At that time, the reservoir was treated with a 2.53 lb. per mil.gal. treatment, followed up on the next day with 1.68 lb. per mil.gal. It had been expected to apply the entire 4.21 lb. per mil.gal. dose on the same day, but the lack of facilities made it impossible. By the third day after the treatments, the count dropped to about 15.

After this series of treatments, *Mallomonas*, to all practical purposes, departed from the scene and *Anabaena* came in. Regardless of treatments of 2.6 lb. mil.gal. on July 6, 2.8 lb. on July 13, and 2.78 lb. on July 15, the *Anabaena* maintained its increase until it reached a count of 800 on August 7. On August 6, the reservoir was treated with a dose of 3.4 lb. per mil.gal. The count increased about 100 on the following day, dropped off sharply for the next three days, and then increased again, despite a dose of 3.75 lb. per mil.gal. on August 15, until it reached a count of 700 on September 1. A treatment of 2.69 lb. per mil.gal. at that time finished the *Anabaena* but brought *Aphanizomenon* into the picture, a change which followed the temperature drop at that point.

On September 11, with a total count of 890 (660 *Aphanizomenon*), a dose of 4.35 lb. per mil.gal. was applied. By the second day after this treatment, the total count had dropped to 250 (200 *Aphanizomenon*), but at that point the trend changed to another sharp increase. Since the count in some parts of the reservoir was much higher than in others, section treatment was tried again. On September 13, Sections 1 and 6 were treated; on September 14, Sections 4 and 5; and on September 15, Section 1, again. In the four days that followed, the count rose from 75 to 1,100, so on September 20, the entire reservoir was given a dose of 3.3 lb. per mil.gal. and this caused an immediate sharp decrease.

By this time, with the heavy summer demands at an end, it was felt that the major difficulties were over. Until that time, the

reservoir had been kept in excellent condition and it had never been necessary to curtail the use of the filters; but between September 20 and October 5, the increase in *Aphanizomenon* was so great that the reservoir, coagulation basin and filters all became "as green as pea soup," and remained that way until October 26. Despite treatments of 3.5 lb. per mil.gal. on September 25, 2.9 lb., on September 28, 3.5 lb., on September 29, and 1.68 lb., on October 6, the trend of the count remained unchanged. Successive treatments of 1.68 lb. per mil.gal. on October 9 and 10 reduced the count from 4,500 to 225, but in nine days it was back up again, higher than ever. Finally, on October 19, a dose of 3.5 lb. per mil.gal. was applied, and this treatment, combined with a drop in temperature, succeeded in eliminating the *Aphanizomenon*.

Conclusions From Experience of 1939

Considerable knowledge accrued from the experience of the year, 1939. Though it was a successful year from the standpoint that any serious emergency was avoided, the success was not unqualified. The reservoir and filter equipment had suffered the effects of decreased capacity at one time and the treatments had not been effective for long enough periods of time. From the various difficulties experienced, however, certain conclusions, which laid the basis for a more successful control procedure in 1940, were reached, as follows:

1. Upper limits of safety, beyond which treatment was necessary, were determined for each organism, as follows:

Organism	*Count*
Asterionella	1,000 to 1,200
Mallomonas	800 to 1,000
Anabaena	600 to 800
Aphanizomenon	300 to 600

It was decided to apply copper sulfate only when any organism reached these limits, as it had proved uneconomical to attempt control when the organism just started to increase.

2. A better knowledge of correct doses of copper sulfate for the various conditions was available.

3. It was known that section treatments could not be applied successfully.

4. A more uniform method of applying copper sulfate was indicated by the brief intervals during which each treatment had effect. It was evident that some spots were being missed in each treatment and

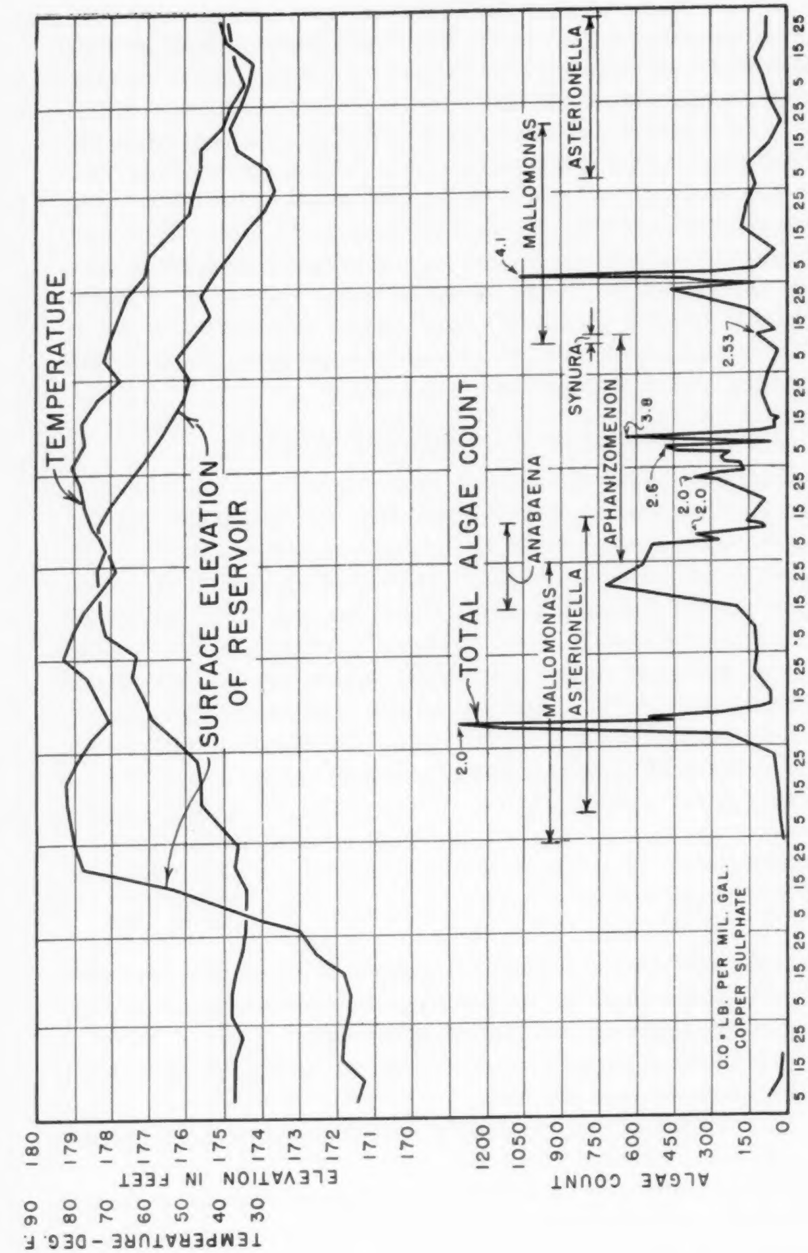

FIG. 3. Reservoir Data for 1940; showing total algae count by weekly average except near treatments, where daily counts are given

that the algae in these areas were left to seed the reservoir as soon as the strength of the treatment had diminished.

New Control System

Acting upon this knowledge, the staff was able to introduce a much more effective system of control. First, time of treatment and doses were planned and section treatments discarded; and then a new system of application was developed.

The new system of application was directed toward the achievement of the best distribution of the chemical. On the basis of the information gained from a blueprint of the reservoir, which showed contours, it was decided that the first step in application should be to distribute 11 per cent of the dose around the shore, continuing in 15 foot strips until this portion was exhausted. The reservoir was then to be divided into two main divisions as shown by the heavy line in Fig. 1. These divisions were to be treated in the usual strip method, working from bank to bank. The dose was then applied, 20 per cent in the smaller section and 58 per cent in the larger one. The width of the strips was kept at the minimum (about 25 ft.) which would allow the workmen time to put in an entire dose in one day. These small strips were maintained regardless of the size of the treatment, the amount of chemical going into solution depending upon the amount exposed to the water. Finally, the remaining 11 per cent of the dose was applied by opening the motor full speed and traveling in strips from one end of the reservoir to the other, at right angles to the other strips. The purpose of this was to help mix the chemical with the water by the waves from the boat. Every effort was made to keep the treatment uniform.

Surface Elevation and Temperature Data—1940

The success of these various changes may be seen by a comparison of the results of 1939 (Fig. 2) with those of 1940 (Fig. 3).

In March, a new pump, which practically tripled the amount of water that could be supplied to the reservoir, when sufficient water was available in the brook, was installed. Its effect is evidenced (Fig. 3) by the sharp rise in the elevation of the reservoir in March and by the fact that the elevation of the reservoir did not drop below 173.6 ft. at any time during the year, although about 230 mil.gal. more water was filtered in 1940 than in 1939. This higher elevation helped keep the treatments uniform in obviating the difficulty with the stumps on the bottom of the reservoir.

During 1940 the temperature went through the same range as in 1939, varying from 35° to 80°F. *Asterionella*, starting in the cold weather again, remained until the temperature reached 74°, and reappeared at a temperature of 46°. *Mallomonas*, starting in the cold weather, dropped out when the temperature rose above 70° and came back when it went down to 70° again.

Anabaena started at a temperature of 74°F. and simmered out at a temperature of 75°. *Aphanizomenon* appeared when the temperature reached 70° and disappeared when it went below 70° again, quite a change from 1939 where it lasted until a temperature of 38° was reached. Some *Synura* was also present at a temperature of 70°.

Treatment Data—1940

The first copper sulfate treatment in 1940 was made on May 8, for *Asterionella*. It was decided to let the count go over 1,000 before treating. On the day the treatment was made the number of *Asterionella* present was 1,126. The effect of the dose of 2 lb. per mil.gal. is evident from the curve in Fig. 3.

The next peak occurred on June 22. This rise affords an interesting picture of the "survival of the fittest." *Mallomonas*, *Anabaena*, and *Asterionella* were all increasing, *Asterionella* in the lead, but none of them reached such a number that it was necessary to treat. Then, with a drop in temperature, *Anabaena* and *Mallomonas* faded out, leaving only *Asterionella*. When the temperature started to rise again, on about July 1, *Aphanizomenon* began to increase and *Asterionella* to decrease.

It had been decided to treat for *Aphanizomenon* when the count reached between 300 and 600. On July 9, therefore, when the count reached 300, the reservoir was given a dose of 2 lb. per mil.gal. This treatment appeared effective, lasting 18 days. When, on July 27, the count again reached 300, the reservoir was again treated with a similar dose, but this treatment lasted only 10 days, and, on August 7, the count of *Aphanizomenon* was up to 400. As the last treatment had not been very successful, it was decided to apply a heavier dose; thus 2.6 lb. per mil.gal. were applied. An immediate drop in the count, on the day after the treatment, resulted; but on the following two days the count increased at such a rate that the number, three days after treatment, was 637. On August 10, then, to assure results, a dose of 3.8 lb. per mil.gal. was applied, and that treatment, finally, eliminated the *Aphanizomenon* for the rest of the year.

During the difficulties with *Aphanizomenon*, it was noted that the type present on July 4 seemed to be in bunches, while that present in August remained in the single strand form. It was decided, therefore, to treat the *Aphanizomenon* of the bunched type with a dose of 2 lb. per mil.gal. and those which remain in single strand form, with as near 4 lb. per mil.gal. as can be applied in one treatment.

In September, enough *Synura* to cause trouble, if it kept increasing, was present. Therefore, with the count at 22, the reservoir was given a dose of 2.53 lb. per mil.gal., and this treatment was effective in eliminating the *Synura* so that it did not return.

Finally, with the *Synura* gone, *Mallomonas* came in again and when it reached a count of 1,000 on October 3, the reservoir was given a dose of 4.1 lb. per mil.gal., the last treatment necessary for the year.

Summary

The success in 1940 may easily be gaged from the comparative costs of treatment. In 1939 the cost of the copper sulfate plus the labor of application was $2,129.52, and in 1940, $658.45, a saving of $1,471.07.

During 1940 the water in the reservoir was deeper than in 1939 and that undoubtedly helped, especially as all treatments in 1940 were uniform and unhampered by stumps. It is felt, however, that most of the improvement was due to three factors of foremost importance of algae control with copper sulfate: (1) knowing when to treat; (2) knowing how much chemical to use per treatment; and (3) being able to apply the treatment uniformly.

The first factor, knowing when to treat, can be determined by microscopic count. Treating should be a preventive measure, not a cure. In other words, treatment should be accomplished before the algae cause trouble, not after.

The second factor, knowing how much chemical to use, is, in the author's opinion, the most difficult problem. We have the table prepared on the data published by Moore and Kellerman as a starting point, but we start, too, with the knowledge that different amounts are necessary to do the same job in different waters, and that different species of the organism require different amounts. According to Whipple,* the amount of copper sulfate to use depends on seven factors:

* WHIPPLE, GEORGE C., FAIR, G. M. AND WHIPPLE, M. C. *The Microscopy of Drinking Water.* John Wiley, New York (4th ed., 1927), pp. 387–88.

1. The kind of algae to be destroyed
2. The amount of organic matter present
3. The hardness of the water
4. The carbonic acid content
5. The temperature of the water
6. The species of fish present
7. The amount of water to be treated

At the present time, the entire matter resolves itself into a problem which depends on the specific experience with the water and organisms at each particular plant. As to the species of fish present, it is felt that the amounts considered as limits can be raised. More fish are killed by the clogging of their gills by dead organisms than from the copper sulfate treatment itself. Many strong doses have been applied at Summit, but few fish have been killed, the only ones being those directly behind the chemical bag, who come in direct contact with the chemical where the concentration is heaviest.

The third factor, the ability to treat uniformly, is simply a mechanical problem, which must be determined entirely upon the basis of the individual characteristics of each reservoir.

Discussion by *Thurlow C. Nelson*.* The excellent paper by Mr. Monie deals with a number of matters of great interest both to the hydrobiologist and to the practical water works operator. In New Jersey, operators are exceptionally free from difficulties due to microscopic organisms, since approximately 65 per cent of the water supplies of the state are drawn from underground sources. This water, if stored at all, is kept in covered tanks of relatively small capacity.

The reservoir of the Commonwealth Water Co. presents three features which make the control of algae especially difficult. With a maximum depth of only 11 ft. when full, it cannot stratify during the growing season, so the nutrients available for algal development are used over and over again giving maximum crops. Second, light at all times reaches the bottom where dormant stages of algae lying on the mud are quickly stimulated to activity whenever temperature and other factors are favorable. Finally, the reservoir being subject to marked fluctuations in level, small bays and inlets, which are often the chief breeding grounds for objectionable algae, are often drained of their contents, thus seeding the entire reservoir again and again.

* Professor of Zoology, Rutgers University, New Brunswick, N. J., and Member, New Jersey State Water Policy Commission.

To the biologist one of the most interesting features of the paper is the light which it throws on critical temperatures for the growth and reproduction of various types of algae. Approximately twenty years ago Doctor Setchell, Botanist of the University of California, pointed out that there are definite ranges of temperature within which various flowering plants began to grow and higher ranges at which they will flower. These critical temperatures were found to lie close to 5°, 10°, 15°, 20°, and 25°C., (41°, 50°, 59°, 68°, and 77°F.). His studies showed that as the temperature passed the critical point certain species were suddenly stimulated to activity. Hydrobiologists working with algae and protozoa are finding similar critical temperatures. Owing to the more gradual temperature changes which occur in the water these ranges are more easily recognized and delimited than is the case with land plants.

Reference to 1939 Data

Referring again to Fig. 2, it will be seen that in 1939 there was a late winter and early spring maximum of algae involving *Mallomonas* and *Asterionella*, and that this first rise in algae came with a water temperature of 39°F. and a falling reservoir level which was draining the shallow margins. Though no temperatures are given from these shallow areas, it is certain that on sunny days temperatures of 41° were attained long enough to stimulate the algae to activity. It is interesting to note the sharp increase which followed the rise in temperature to 41° just before the first treatment. The sharp fall in algae early in March followed the treatments employed, but the rise in temperature above 50°, the second critical point, was succeeded by a sharp increase in algae which was promptly squelched by the use of copper sulfate.

Total algae, except for *Mallomonas*, remained low through the summer due to the absence of blue greens. These, however, came in with a grand outburst of *Anabaena* and *Aphanizomenon* in the late summer and early fall. During much of the time that these algae were getting under way the temperature fluctuated about the critical point of 77°F. Note also that the reservoir level was falling throughout this period.

Hale states that no proof has been established that *Anabaena* has caused the death of cattle (1, p. 35). Observations by Fitch and his co-workers (2), however, show that cattle and sheep have been killed in numbers within a few hours after drinking water heavily loaded

with *Anabaena*. Its effect upon humans is unknown, but may not the gastro-intestinal disturbances so frequently encountered in late August and early September be connected with the disintegration of blue greens on the filter and the passage of toxic products into the distribution mains?

The persistence of *Aphanizomenon* over most of the fall and through a wide falling temperature range would seem at first glance to upset the idea of a critical temperature effect. Mr. Monie, however, points out that two different forms of this blue green were present in July and in August. It would be of great interest to learn whether this alga might also show what are called physiological species or varieties, that is species, though the same in appearance, having different critical temperatures. The writer is convinced that this is true of *Synura*, one species flourishing under the ice at temperatures just above freezing, and a second type holding sway between 50° and 60°F. Mr. Monie calls attention to the fact that *Asterionella* is a cool weather form fading out, he believes, as much from the increase in temperature as from the treatments which he employed.

To sum up the year 1939, therefore, it is seen that the typical spring and fall algal maxima prevailed, with the diatom *Asterionella* and the yellow brown alga *Mallomonas* ushering in the season, blue greens dominating during warm weather with *Asterionella* reappearing in the late fall.

The picture in 1940 was quite different. The winter was severe and spring was almost a month late. Whereas in 1939 the spring algae peak came about March 1, with a temperature of 41°F., in 1940, it did not occur until May 9 and then at the third critical temperature, 59°F.

Reference to 1940 Data

It is to be noted again from Fig. 3 that the first great crop of algae came immediately after a fall in the reservoir level, late in April and early in May. It is possible that the long delay in appearance of algae in the spring of 1940 may have been correlated, in part at least, with a steadily rising level of the reservoir from late February to the middle of April. The temperature, also, in 1940 did not reach 41° until April 6, whereas in 1939 this temperature was attained once in February and was maintained above that point from March 6 on. The same forms, *Mallomonas* and *Asterionella*, were involved. In 1940, however, the blue greens started about a month earlier, but

were held in check. Had this not been done the condition of the reservoir by August would, no doubt, have been worse than in October of 1939. Note, too, the reappearance of *Asterionella* in the late autumn. Attention is also called to the fact that the rise in algae in June, in August, and in September occurred in each instance with a falling reservoir level.

Mr. Monie is to be congratulated on his work, particularly on his method of sampling from a number of points *in the reservoir itself*. The writer is much disturbed by the reservoir control laboratories in the state which draw their samples from the main after it has left the reservoir or after the water has passed the pumps. Delicate organisms like *Synura* are broken up by such passage, while as Hale notes (1, p. 12), *Aphanizomenon* becomes practically unrecognizable. It must be emphasized that samples for microscopic examination drawn from the mains *are of very little value*. For bacteriological examination such samples are satisfactory, but for organisms larger than bacteria, such samples give a wholly inadequate picture of what is going on in the reservoir. Obviously it is much more comfortable, on a cold or stormy day, to draw a sample from a tap, but the conscientious hydrochemist or hydrobiologist will live as close to his reservoir as he possibly can. He will watch it day by day, studying its peculiarities. As the years pass he will be rewarded, for he will come to know his reservoir as a wise physician knows his star patient. With his eye on the calendar, the thermometer, the sky and the reservoir level, he will be able to predict, with a high degree of accuracy, the time of appearance of the various trouble makers in the water. Just as the doctor by a small preventive dose can often stave off a serious illness, so the reservoir operator can often, by prompt action, remove algae in their initial stages by small quantities of copper sulfate. If he delays he must use far larger quantities of the salt, for, in its destructive action on algae, copper sulfate combines with the substance of the plant, probably with the gelatinous film that surrounds all blue greens and diatoms. The greater the number of such organisms, the more salt must be used. Not only does this increase the cost, but the destruction of large numbers of algae liberates their noxious products into the water resulting in widespread complaints.

Mr. Monie shows a saving, in copper sulfate, of over $1,400 in one year, by wise spacing of treatments. Let any plant operators whose other duties prevent them from making microscopic examinations

daily or at least every other day bring home to their governing bodies the economy which results from *adequate* control. Often the savings will more than pay the salary of an additional man, thus freeing the operator for this most essential task.

The writer has but one practical suggestion to make to Mr. Monie. Whipple (3), Goudey (4) and, especially, Hale (1) stress the excellent results, at times, from spreading crystals of copper sulfate instead of using the solution. In view of the fluctuating level of the reservoir and the presence of stumps, it is suggested that, early in the spring before the water temperature reaches 40°F., crystals of copper sulfate be strewn along the shallow margins of the reservoir. To make this a scientific study, one side of the reservoir might be so treated and the other left alone. By taking samples in the shallow water on both sides the effects of the treatment could be measured.

In closing the writer wishes to emphasize one short but pregnant paragraph in Mr. Monie's paper:

"The first factor, knowing when to treat, can be determined by microscopic count. Treating should be a preventive measure, not a cure. In other words, treatment should be accomplished before the algae cause trouble, not after."

In these few words are contained the essence of effective algae control by copper sulfate. Adherence to such a policy has proved itself in making possible both economies in cost of chemical and the delivery of a far superior water.

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Relation of Willamette Valley Project to Water Supply

By John C. H. Lee

THE Army Engineer project for the Willamette River in Oregon (Fig. 1) will, in some manner, affect nearly every enterprise within the valley. While it is popularly accepted for its promised benefits in flood control, navigation, power and irrigation, not the least of its advantages will lie in substantial benefits to municipal and industrial water supplies and in the reduction of stream pollution from municipal and industrial wastes.

In pioneer days Willamette River water was clear and potable without extensive purification. While modern indices of water quality were not in vogue then, the quality of a normal low water sample would probably have been represented about as follows: turbidity, 15; color and odor, none; hardness, 50 p.p.m.; and pH, 7.2. During the higher stages of the river, the turbidity, naturally, would increase somewhat, but even so, sedimentation was the only treatment required, even by the most fastidious.

River pollution had its so-called civilized inception with the first community and the first crude manufacturing plant to occupy the banks. Obviously the degree of this pollution has been growing with population and industry and will continue to grow until modern treatments for municipal and industrial wastes are made fully effective. Meanwhile, considerable relief may be afforded through the augmented low water flow of the Willamette to be achieved by the project.

Portland's first water supply came from Willamette River. The initial public withdrawal was taken by means of a pumping plant located a short distance upstream from Sellwood Bridge. By 1894,

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however, pollution had become so pronounced that the city turned to a supply from Bull Run on the slopes of Mount Hood, its present source of supply.

Oregon City in 1915, discarding its filtered and chlorinated Willamette supply, reached out 25 mi. and tapped the South Fork of Clackamas River.

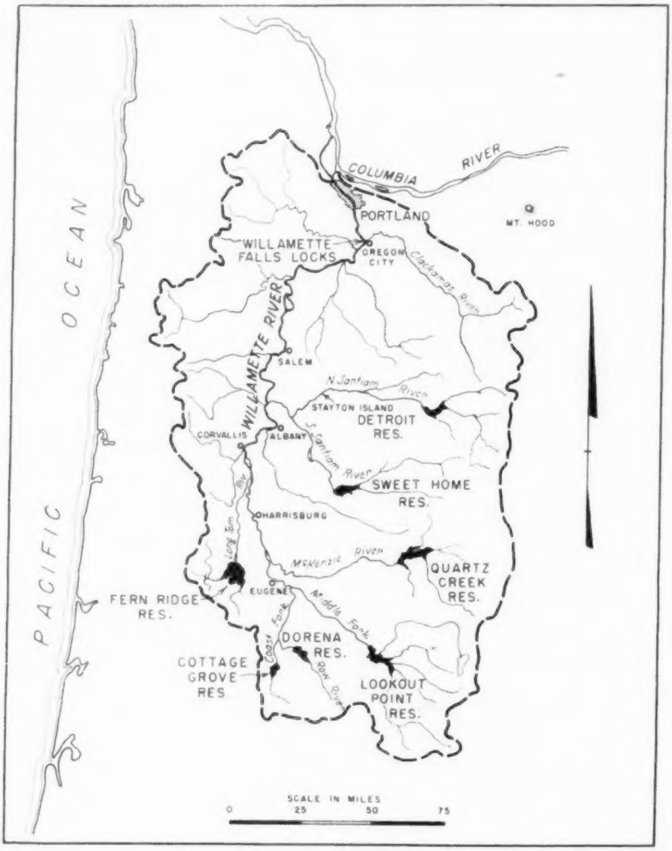

FIG. 1. Section of Oregon; showing area of the Willamette Valley Project

Eugene suffered a typhoid epidemic in 1906 and 1907. Thereupon the city immediately acquired its then privately-owned system, and put in a rapid sand filter plant. It continued to use Willamette River water until July, 1927, when a change was made to McKenzie River water, supplied through a modern filter plant.

Salem used Willamette River water, drawing it through river bed gravels by a pumping plant until October, 1937, when a change was made to a Santiam River supply with an intake at Stayton Island.

Albany has for many years used Santiam River water brought in through a power canal.

These up-river cities are mentioned merely as illustrations because their supplies will, in some measure and in varying degrees, be affected by the Willamette Valley Project when it is completed. In each case the effect, it is felt, will be beneficial. Eugene's supply will be taken from the McKenzie River below the proposed Quartz Creek dam. Salem's and Albany's supplies will come from the Santiam River below the Detroit and Sweet Home dam sites.

Whatever pollution or algae growth there now exists must be lessened by the increased flow that will obtain during low water periods as a result of the contemplated river regulation. Since water released from the well-balanced reservoir system during flood times will be much clearer than otherwise, high turbidities should be reduced and the amount of coagulants now needed during such periods lessened.

Definition of Project

The adopted Willamette Basin Project is a multi-purpose plan conceived primarily in the interest of flood control, but carrying additional large benefits to navigation, power, irrigation and stream purification. The author's predecessor, General Robins, proposed the project to Congress, through the War Department, as a two-step development, designated as the "Initial Development" and the "Co-ordinated Plan." The principal items of construction, as will be outlined later, are the reservoir dams. In the Initial Development these will be built to provide only the capacities required for flood control and attendant benefits to navigation, irrigation and pollution alleviation (a total of 1,345,000 acre-ft.). In the Co-ordinated Plan such initial dams for three of the reservoirs will have to be increased in height to give an added capacity of 475,000 acre-ft. in the interest of power development.

The estimates to be quoted in this paper are for the Initial Development only, that is, for flood control and attendant benefits. Power now available, or shortly to be made available, from Columbia River sources, will probably tend to defer, for a number of years, the

building of the project to the full extent proposed in the Co-ordinated Plan.

The valley public has become flood conscious through increased utilization of the rich bottom lands along the main Willamette and its tributaries. The growing of specialty crops and the gradual encroachment of towns and cities upon the flood plain of the main stream, during the past seventeen years of immunity from severe flood, have created a flood vulnerability unknown in earlier years. In recent years the public, warned by unprecedented high floods in other sections of the country, has begun to organize and to demand insistently that the Government provide something in the way of flood control for the Willamette.

In response to this public demand, the Army Engineers, acting under instructions from Congress, made, in 1934, a preliminary flood control investigation of the Willamette and its tributaries. That preliminary report was followed by a more detailed survey during 1935 and 1936. From the basic data thus assembled there was prepared, under the direction of Colonel, now General, Robins, Division Engineer, and Colonel Milo P. Fox, then District Engineer, a report which, when submitted, resulted in the inclusion, by Congress, of authorization for the construction of the Willamette Basin Project in the Flood Control Act of 1938. This fortunate outcome, it may be stated, resulted from the united efforts of the Oregon delegation and delegations from the other states of the Pacific Northwest.

The history of the activity which has brought the project to its present partial completion begins in 1934 with the first investigations in the valley. The resolution of the problem in this study and those of the following two years involved a three-part program, as follows: (1) ascertaining flood damages; (2) working out plans for, and estimating the cost of, flood control; and (3) appraising the benefits in relation to the costs. It is this program which will be described in the following pages.

Investigation of Flood Damage

Following the usual procedure in the investigation of flood damages, the first step taken was a consideration of the great floods of the past, which had occurred in the valley. In this survey, records showed that only four floods producing a discharge of 350,000 sec.-ft. or more had occurred at Salem since the settlement of the valley by white

men. Those four floods occurred as follows: in December, 1861, producing 500,000 sec.-ft.; in January, 1881, 428,000 sec.-ft.; in February, 1890, 450,000 sec.-ft.; and in January, 1923, 350,000 sec.-ft.

Application of the probability theory to these results indicated an expectancy of a flood with a maximum discharge of 600,000 second-ft., or 20 per cent greater than that of 1861, at Salem at some future date.

Following the standard Army Engineer practice that any recommendation for a Federal project in the interest of flood control must be soundly supported by facts and figures, much care was used in the field work of assembling flood damage data. To this end the flood plain of the Willamette and its principal tributaries was divided into eighteen zones, in seventeen of which field surveys were necessary. The actual flood damage appraisals, insofar as possible, were made by local men who, through experience as assessors or deputy assessors in their respective counties, had become thoroughly conversant with rural and urban land values, as well as with flood damages.

As a result of the actual field survey, flood damages were assembled under the eleven headings, as follows:

Land surface and farm crops	Urban properties and services
Permanent land damage	Highways and bridges
Farm improvements	Highway interruptions
Livestock	Railroad properties and services
Suburban residential properties	Bank erosion
Suburban business properties	

From all the data thus assembled logical estimates were made of the flood damage that would occur under present conditions of development in the valley with the recurrence of record floods, i.e. with floods similar to that of 1861, with an expected frequency of 100 years, and similar to that of 1927, with an expected frequency of 5 years. The resulting estimates revealed that each repetition of the 1927 flood, uncontrolled, would submerge some 273,000 acres in the Willamette Valley at a damage loss of more than $4,000,000, while a repeated 1861 flood would inundate no less than 353,000 acres with damages amounting to about $11,000,000.

It may be of interest to note that the damage caused by a flood equal to that of 1861 divided by 100, its computed frequency, gives an average annual loss of $106,000, while the damage caused by a flood equal to that of 1927, divided by its frequency of 5 years results

in an average annual loss of $830,000, or nearly eight times as great, on an average. This means that the frequently occurring normal floods through the years actually inflict more damage than do the abnormally large floods of infrequent occurrence.

As a result of all these investigations, the average annual damage was placed at $1,693,000 and this amount became the answer to the first part of the program of resolving the problem.

Location of Sites

With the second part of the problem came the careful consideration of all possible means of flood control, including both levees and reservoirs. Flood control in the Willamette Valley was found to be possible by both methods. Levees, however, could claim benefit only for flood control, whereas reservoirs would benefit navigation, irrigation, power, and stream purification as well. This multiple benefit is made possible by the fact that floods in the Willamette and its tributaries invariably occur in winter. For this reason, the preliminary estimates sufficed to demonstrate that reservoirs were initially preferable to levees for the comprehensive control of floods.

This multiple use of reservoirs is characteristic of Pacific slope streams. To attempt such projects in other sections of the country, in which floods are not so definitely limited to one season, would probably end in disaster, since, sooner or later, the reservoirs would be full when, for flood control use, they should be empty.

Selecting the several Willamette reservoir sites and dam sites required as much care, and, indeed, involved much more work and expense than did the making of flood damage appraisals. It was, in fact, the "*piéce de rèsistance*" of the entire investigation.

Typical V-canyon type of topography along the tributaries of the Willamette in both the Cascade and Coast Ranges of mountains did not offer very favorable opportunity for the discovery and construction of storage reservoirs at a nominal per acre-foot cost. For this reason the investigation had to be extended to cover some 78 tentative reservoir or dam sites, with some of the reservoir sites overlapping. For some of these, the investigation consisted only of a review of existing data, followed perhaps by a reconnäissance; and for others, the study was extended to include a rough preliminary survey. In the nineteen most favorable locations, the reservoir areas were mapped by the plane-table method to a scale of 1,000 ft.

to an inch and the dam sites to a scale of 100 ft. to an inch; and the more favorable dam sites were explored by drilling and the digging of test pits, so far as funds available would permit. The final result was the selection of the seven recommended sites shown in Fig. 1.

The Fern Ridge site on Long Tom River, 12 mi. northwest of Eugene, will store 95,000 acre-ft.; the Cottage Grove site on the Coast Fork, 6 mi. south of Cottage Grove, 30,000 acre-ft.; the Dorena site on Row River, 6 mi. east of Cottage Grove, 70,000 acre-ft; the Lookout Point site on the Middle Fork, 37 mi., by the Willamette Highway, from Eugene, 340,000 acre-ft.; the Quartz Creek site on McKenzie River, 43 mi., by highway, from Eugene, 335,000 acre-ft.; the Sweet Home site on South Santiam River, if the dam be placed at the westerly limit of the town of Sweet Home, 310,000 acre-ft.;* and the Detroit site on North Santiam River, 6 mi. downstream from Detroit, 165,000 acre-ft. Total usable storage for all these sites, then, is 1,345,000 acre-ft.

Costs of Construction and Operation

In the estimate of cost it is shown that the initial development of the project involves $92\frac{1}{2}$ per cent of expenditures for reservoirs and $7\frac{1}{2}$ per cent for other features, by the following four-item estimate of construction cost:

Reservoirs	$57,475,000
Oregon City Lock	2,500,000
Open River Improvement	1,100,000
Fish Facilities	1,000,000
Total	$62,075,000

It will be noted that immediately following "Reservoirs" is listed the "Oregon City Lock." The present locks at Oregon City, consisting of four chambers each with a usable space of only 37 by 175 ft., constitute a veritable bottle-neck in the transportation of logs in rafts from the timber areas of the upper Willamette to the sawmills at Portland. The new construction will consist of a single lock with a lift of approximately 50 ft. and a usable space of 56 by 400 ft. To break up a 50 by 350 ft. log raft, pass it through the present locks and

* Owing to the fact that the Town of Sweet Home has enjoyed a substantial growth since the survey was made in 1936, it is possible that the South Santiam dam may be shifted and the required storage provided at another site or sites.

assemble it again now requires about $2\frac{1}{2}$ hr.; while passing the large raft intact through the enlarged lock will require only about $\frac{1}{2}$ hr. This seemed to be ample reason for including the new lock in the program of construction.

Consideration of costs on the project, of course, included the determination of costs of operation. In their estimation, figures were based to some extent on the expected procedure of operation, which was assumed, for these purposes, to be as follows:

1. By about November 15, or the time when floods may be expected, the reservoirs will be emptied through their low-level outlets.
2. They will then be kept empty until about the middle of February, except as filled, or partly filled, and duly emptied again for flood control.
3. On about February 15, the low level outlets will be closed, or partly closed (the date depending somewhat on the snow in the mountains), and the reservoirs be allowed to fill, a full stage being reached about June 1.
4. Later in the summer the water will be drawn off as required in the interest of navigation, irrigation, and power.

The estimated annual cost, based on this proposed schedule of operations, and including interest (4 per cent), amortization (50 yr.) and maintenance, for the Initial Development, was $3,200,000, allocated as follows:

Reservoirs	$2,917,000
Oregon City Locks	138,000
Open River Improvement	50,000
Fish Facilities	95,000
Total	$3,200,000

Appraisal of Benefits

In appraising the benefits to be derived from the Initial Development of the project, the total, in terms of money value, was estimated to be:

Flood Control	$1,526,000
Navigation	834,000
Irrigation	519,000
Power	157,000
Stream Purification	90,000
Total	$3,126,000

In regard to benefits to flood control, it has been shown under the first phase of the problem that the average annual flood damages without storage would average $1,893,000. It has further been estimated, though the calculation is somewhat too involved to explain here, that the average annual loss with reservoirs would still amount to $349,000. This leaves a credit on this account of $1,344,000. Further still, it has been estimated that an annual credit of $182,000 may be taken as a result of enhanced property values, assuming an interest rate of 5 per cent. This gives a total annual credit to flood control of $1,526,000 as shown in the tabulation.

In regard to benefits to navigation, the storage released from the reservoirs in the Initial Development would result in a minimum of 5,000 sec.-ft. and a stage of 5 ft. in the main river as far as Albany and of 6,500 sec.-ft. and a stage of 6 ft. as far as Salem and on to the mouth of the Santiam, 14 mi. below Albany. This, with the rapidly increasing downstream traffic in rafted logs, induced by depletion of the lower Columbia supply, and together with the economies resulting from the new Oregon City Lock and the improvement of the open channel conditions as provided for in the $1,100,000 set out in the estimate, will make a total estimated annual benefit to navigation of $834,000.

In regard to benefits to irrigation, the Willamette Valley, in common with other areas in a westerly direction from the Cascade Range, is partially deficient in moisture during the growing season. Thus, supplemental irrigation is essential to the growing of specialty crops, such as those now being produced in increasing quantity, and to dairying. On this account there has for a number of years been a gradual increase, and now a more rapid one, in the areas irrigated, until in 1938 the total was estimated at 25,000 acres, mostly in small tracts.

A survey made by the U. S. Department of Agriculture and the Oregon State Experiment Station resulted in an estimate of 1,373,000 acres of irrigable lands in the Willamette Valley, 695,000 acres "good" and 678,000 "fair." Investigations in connection with the preparation of the Willamette Project Report showed that 224,000 acres of favorable lands, with a water demand of 358,000 acre-ft., could be irrigated by water supplied from the reservoirs proposed for this project at a cost which would justify the crediting of $2.32 per acre, or a total of $519,000 as a benefit to irrigation.

In regard to benefits to power, the increased summer flow in McKenzie River, resulting from the construction of the initial Quartz Creek Reservoir, should make possible an increase in the firm power output of the present Leaburg and Walterville plants, belonging to the City of Eugene, with their water wheel and generator capacities increased to utilize the greater flow, thus adding an estimated annual value of $73,000. In the same way, the increased low flow in the Willamette, resulting from the construction of all the reservoirs, would make possible an increase in generation through the wheels now installed at Willamette Falls, Oregon City, having a net annual value of $84,000, thus making the total benefit to power in the Initial Development, $157,000.

Finally, in regard to benefits to stream purification, the proposed release of stored waters, during the summer, in the interest of navigation, irrigation, and power will increase the low flow in the upper river threefold and in the lower river twofold. This, in deferring the time when treatment will be necessary, has been calculated as having an annual monetary benefit value to stream purification of $90,000.

As the estimated annual costs have been shown to amount to $3,200,000 and the annual benefits to amount to $3,126,000, the conclusion was reached that the Willamette Basin Project Initial Development was economically feasible.

The Co-ordinated Plan

As previously stated the Co-ordinated Plan differs principally from the Initial Development in that under the former the dams for the Lookout Point, Quartz Creek and Detroit Reservoirs would be increased in height to give a power head and an added storage capacity of 475,000 acre-ft. in the interest of power development. The calculations and deductions as to costs and benefits for this plan need not be given, since they are very similar to those already given for the Initial Development and for the further reason that the amounts of power now becoming available from Bonneville and Grand Coulee Dams seem to place the construction proposed for the Co-ordinate Plan at some distance in the future.

The statement may appropriately be made, however, that calculations reveal it to be warranted and expedient in the Initial Development to expend the sum of $3,275,000 for installing the penstocks and for doing other work which will be of benefit to the later raising of

the dams to the heights called for in the Co-ordinated Plan. Neither in the Initial Development nor in the Co-ordinated Plan, however, is it proposed to expend money in the interest of irrigation, power development and stream purification other than for providing the storage as already covered in these remarks.

In conclusion, it is to be recalled that with stream purification cited as the culminating benefit from the flood control reservoirs, the consideration of the Willamette Basin Project and its relation to water supply is again the primary question. While the water will not be restored to the purity and potability of pioneer days, it will, by the addition of some 3,000 sec.-ft. of pure mountain water from the reservoirs of the Willamette Basin Project increasing the discharge at Salem to 6,500 sec.-ft. and to upwards of 7,000 sec.-ft. below the mouth of the Clackamas, be a much improved supply.

Twenty-Five Years Advance in Water Works

By William W. Brush

IN PRESENTING a résumé of what has been accomplished in water works during the past twenty-five years one must, logically, first consider the rainfall and the resultant water available as the source of supply. While there has been no advance in either the amount, distribution or chemical constituents of rainfall that can be properly claimed by water works engineers, the knowledge of the amount of rainfall and its fluctuations throughout the country has been advanced by the establishment, during this period, of thousands of rainfall gaging stations. Coupled with the great increase in rainfall recording has come the setting up of stream-flow gaging stations, where automatic records of stream levels have multiplied manyfold the previous known runoff of both large and small watersheds.

The measurement of flood flows has resulted in an increase in the spillway capacity provided for water supply reservoirs and shown that for watersheds with an area of a few square miles, the flow may reach a peak of some 2,000 cu.ft. per sec. per sq.mi. of tributary area. Eastern dams have been constructed with spillway capacities designed for over 500 cu.ft. per sec. per sq.mi. of watershed.

The severe drought of ten years ago in the eastern half of the United States demonstrated the inadequacy of many surface supplies and some well developments. From this experience have come increases in supply sources and scaling down of estimates of dependable yield. In the New York system for both the Catskill and Croton watersheds, the previously assumed dependable yields were reduced by some 10 to 15 per cent. Instead of estimating the yields on low stream flows and utilization of all the water held by storage reservoirs, in the New York system, it was assumed that 25 per cent of the total

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storage capacity should be considered as a reserve that would not be included in computing the available supply based on estimated minimum stream flows and total storage capacity of the reservoirs.

The author considers the present-day more conservative estimates of water yields to be a definite advance, but to go still further on the conservative side in estimating the supply available, especially from surface streams and storage, should be the aim of those who wish best to serve their communities by providing a sufficient supply of water to meet demands during the droughts of the future which may be even more prolonged and severe.

Flood Forecasting and Protection

Of interest to water works operators is the development of a scientific system of flood height forecasting which has been worked out and put into use in very recent years. In this work and in rainfall and stream flow measurements, there has been a collaboration of the U. S. Geological Survey, the U. S. Weather Bureau and state agencies. The relationship between rainfall and floods on small watersheds and on the combination of such watersheds in large drainage basins has been developed in Pennsylvania both as to time and resultant flood levels, so that information can be given sufficiently in advance either to prevent damage or to minimize the damage and the extent of interference with water supply systems.

As storms that create floods are likely to interfere with telephone communication, especially to comparatively isolated points where rainfall records would be taken, a radio transmission system has been developed in Pennsylvania to prevent storms from interfering with the prompt communication as to rainfall and stream flows.

The space available will not permit a recital of the advances made in the protection of water supply systems in the Ohio River Basin following the unprecedented floods of January and February, 1937, which cut off the water supplies of Cincinnati and Louisville as well as many other smaller communities; nor will it be possible to dwell on the dangers that may come from assuming that droughts or floods of a severity that would be expected once in a hundred years will actually be separated by such a span of time. The fallacy of such assumptions was strikingly demonstrated in New England where the flood of 1936, of a severity such as might be expected once in fifty or more years, was followed two years later by the hurricane and floods of September, 1938, which developed stream flows of amounts expected only once in 100 to 300 years.

Recreational Use of Watersheds

The recreational use of watershed areas, including reservoirs, is a highly controversial subject. On the one side, there is the view held in New England and in other areas in the East that the public should be kept off watershed areas and water supply reservoirs as far as possible. In the areas where lakes are less numerous, such as the Midwest and West, the recreational use of both watershed lands and water supply reservoirs is both advocated and practiced. The author believes that the development of what he would term a rational controlled use of such areas is an advance in water supply practice and should be encouraged. An excellent example of this type of use is at Springfield, Ill., where the municipal authorities developed a large water supply lake some five miles from the city. Controlled and treated bathing areas have been made available in the lake and are very popular. Home sites are open to the public on long term leases and numerous picnic areas and playgrounds have been established on the city-owned land surrounding the large artificial lake. All such use is under rules and regulations providing for the adequate protection of the public water supply from pollution that would menace the health of the consumers. The water from the lake is filtered and chlorinated.

In masonry dam construction, the most striking feature in the past 25 years, has been the design and successful completion of larger and higher dams than ever before attempted, with Boulder Dam as the best known of such structures.

In earth dam construction, the development of the science of soil mechanics and a better understanding of how to secure the most thorough compaction of soil and how to increase its resistance to water penetration has led to new laboratory and field technique in handling soils and in selecting and placing soil in dams. With the powerful tractors, graders and other machines for transporting soil available, the unit cost of earth dam construction has been kept down even though labor costs have risen.

Transportation

The use of pressure tunnels driven through rock and lined with concrete has been extended for large supplies, notably for the new Delaware supply for New York City, where a continuous rock tunnel about 85 mi. in length will bring the water under the mountains,

valleys and the Hudson River to join with the Catskill system. By the successful development of time delay fuses and tunnel mucking machines, the speed of driving the rock tunnels has been greatly advanced and the cost kept down.

The Southern California Metropolitan Water District has virtually completed the largest single water supply system developed for the transmission and delivery of a general water supply. Parker Dam, about 150 mi. below Boulder Dam, forms a reservoir in the Colorado River valley, from which water is delivered 242 mi. to a terminal reservoir in Southern California. In this distance, the aqueduct has 92 mi. of tunnel, 55 mi. of cut and cover conduit, 63 mi. of open lined canal and 29 mi. of inverted siphons. The entire aqueduct is to have a continuous flow capacity of 1,500 cu. ft. per sec., based on a computed capacity of 1,605 cu. ft. per sec., thus allowing for short interruptions of flow, but in some of the inverted siphon sections, only one of the two pipes has been installed.

The cost of the work, up to and including the terminal reservoir, is approximately $200,000,000. To this sum is to be added the cost of the extensive distribution system to carry the supply to the thirteen cities in the District and of the softening and filtering plant.

Reinforced concrete pipes have been noticeably perfected and are now being made for pressure conduits up to $12\frac{1}{2}$ ft. in diameter.

In the large steel pipe field, the past 25 years have seen the production of the electric-fusion-welded joint and the virtual elimination of the riveted and lock-bar joints. With the welded joint, a lower cost pipe is secured, and the joint, if properly made, has a strength equal to the plate metal. The advance in cast-iron pipe and pipe lining will be discussed later under another section, although cast-iron transmission mains are continuing to have their place in the field.

Pumping Equipment

In pumping equipment, 25 years have seen the elimination of the slow moving plunger pumps and the substitution of the rapidly revolving centrifugal pump. This change has been accompanied by a remarkable improvement in the efficiency of the centrifugal machines, which now reach about 90 per cent in some of the very large units, such as those installed for the Colorado River supply for the Southern California Water Commission. The number of stages required for pumping against high heads has been greatly reduced. Electric motors have continued to be the power units most frequently used

to drive centrifugal pumps, but comparatively light speedy diesel engines are not infrequently now competing successfully with electric drive. While the steam boiler, with its present-day high pressures, has moved far forward in fuel economy, and the steam turbine has kept up with other prime movers, the steam turbine is not often used in pumping station equipment.

As a standby unit, the gasoline engine has come in, coupled to a centrifugal pump with the diesel engine a less frequent standby. The cost of fuel for the gasoline engine has prevented its use for regular operation.

With the possibility of sudden stopping of electric-driven pumps, due to current failure, the importance of suitable valves to control the flow and, if possible, to prevent water hammer, has become manifest. The cone-type valve with automatic operation has been one of the widely used products brought forward during the past 25 years. In this period, there has been developed, in a practicable manner, the theory of pipe-line surges, commonly called water hammer, and how excessive rise in pressure from such surges may be avoided. While the majority of water works operators are not sufficiently conversant with this subject to work out, unaided, the definite answer to water-hammer problems, such problems can now be solved by those who have kept up with the developments in this direction during the past several years. It is now known that the prevention of the pressure surges, which cannot be kept within allowable limits by air chambers and regulation of rate of valve closure, can be suitably limited by relief valves, which will open on the pressure drop following the stoppage of the water supply and be in the open position to discharge the water as the rising surge travels back to the pumping station.

Other very valuable aids in pumping station operation that have been developed during the period under consideration include automatic starting and stopping of station units within desired pressure ranges; distance control of operation, and signals showing what is taking place in stations so operated; automatic stopping of machines if bearings heat up; long distance transmission of reservoir and tank levels; and radio communication, either as a substitute for telephone or as an auxiliary, to avoid failure in sleet storms and thunder storms which might put the telephone system out of commission. This list necessarily gives only some of the many devices which have been

developed to aid in the safe and economical operation of water works pumping stations and which were not available 25 years ago.

In the distribution system, the advances both in number and character have been in connection with the pipe rather than with the valves, hydrants, corporation stops and services.

New Law of Design of Cast-Iron Pipe

The extensive investigation of cast-iron pipe carried on by A.S.A. Committee A21 under Chairman Thomas H. Wiggin, has developed a new law of design for cast-iron pipe. This new law takes into consideration the pressure, depth of cover, water hammer or truck load (whichever is the more severe), method adopted for pipe laying, and physical characteristics of the metal determined by tests made of the metal as contained in the finished pipe.

The new design law, effect of different methods of laying and backfilling of trench, effect of truck loads, strength and other physical properties of the metal as it forms the pipe, together with a new specification for pit-cast pipe, were developed in a fourteen-year study which included a vast number of experiments and the destruction of many full-size pipes up to 48 in. in diameter.

While, during the past 25 years, pipe centrifugally cast in sand or water-chilled molds has largely displaced pit-cast pipe, the studies and experiments of Committee A21, supplemented by those carried on at the various foundries, will shortly be developed into specifications for the various special types of cast-iron pipe which are commercially produced.

Twenty-five years ago, no cast-iron pipe foundry would furnish an adequate protective coating for its product when exposed to an active water. The coal-tar dip was universally applied, and past experience showed that, with active water, approximately 2 per cent of the carrying capacity of the ordinary size distribution main would be lost yearly by tuberculation of the pipe wall.

Now, largely due to the pioneer work of James E. Gibson, effective protective linings of cement mortar can be secured at little or no extra cost. Centrifugally-applied coal-tar enamels are also available as well as some other special coatings. This protection of the interior of the smaller distribution pipes is one of the very valuable advances made, but one which does not seem to be as generally recognized and appreciated as would be desirable.

Mention has already been made of the development of fusion-

welded steel pipe, which has been produced for practically all sizes of pipe for distribution use. In addition, the engineer now has available the asbestos-cement pipe which was developed in Italy but which during the past 25 years has been introduced into this country.

The first serious attempt to bring standardization into the water-meter field was begun over 20 years ago and has developed into the meter specifications which were approved in 1923 and which are now on their way to revision. There have been no radical changes in the general design of disc and current meters. A few years ago a displacement meter constructed on an entirely new principle was introduced and is now in competition with the disc type.

Elevated tank storage is a most valuable and economical addition to the majority of water distribution systems. The ugly standpipe, with much of its contents at too low a level to furnish adequate pressure, was the structure generally erected prior to the present-day large capacity elevated tank. The past 25 years have witnessed the evolution of this type of elevated storage both in the large capacities made available and in the pleasing designs for the tank outlines and its supports.

Development of Cathodic Protection

With active waters, the protection, from corrosion, of the interior of such tanks has been a problem and an expense. To clean and repaint the interior meant the loss of the valuable storage for several weeks, as well as a material expense. As a substitute for painting and as a more effective protection of the metal, the electric or cathodic protection of all tank and pipe riser surfaces in contact with the water has been developed and successfully applied. The author has, during the past two years, listened to many papers and discussions on this subject and in no case was there any intimation that this type of protection had shown any evidence of failure to eliminate further corrosion and to remove gradually the products of earlier corrosion.

The recent establishment, by A. W. W. A. and N. E. W. W. A., of new specifications for valves, hydrants, pipe laying and the development of a system of recording distribution system data will undoubtedly result in an improvement in the valves and hydrants produced and in the installation of pipe and appurtenances. Such improvements are, however, receiving only a gradual introduction into actual practice.

Employment in a water system furnishes an experience that is too specialized ordinarily to be of much value in securing other employment. The changes that most frequently occur in the water works forces are those due to political changes in municipalities that follow the philosophy that "to the victor belong the spoils." Such changes obviously do not offer an opportunity to qualified water works operators to change their positions for better and permanent ones. The municipal operators must, therefore, look to advancement in their own community with the realization that such advancement is likely to be slow.

Pensions, Civil Service and Social Security

This employment situation naturally develops a strong desire on the part of operators to remain in their positions as long as they are capable of carrying on their work satisfactorily and to make provision for a pension during the years they may live following retirement.

The large number of municipal operators who are removed each year and replaced mainly by untrained men is a menace to the health and property of the consumers. To minimize such changes, the extension of civil service and the licensing of operators have appeared to be the means which might secure sufficient public support to be adopted.

There has been a gradual extension of the civil service system in the United States, but so far it has been applied mainly to the larger cities. Licensing of operators has developed virtually entirely within the past 25 years and there are about 20 states in which it is practiced, the majority using the volunteer system. No state has given up licensing after once adopting it, and while licensing does not cure the evil of changing operators due to political reasons, it is considered to reduce gradually the number of such changes and to raise the standing of the operators. In this work, the various state health departments have been most helpful in their support.

Twenty-five years ago, pension systems for municipal water works operators were practically non-existent. During the period since then, some very adequate systems have been developed, such as those for New York City and Los Angeles; and a number of states, notably, New York and Massachusetts, have set up pension systems which may be, and have been, applied to their cities. In spite of the advances made toward pensions, the majority of municipal operators now have no financial security for their old age. The private com-

pany operators come under the Federal Social Security Act and bills have recently been introduced in Congress to extend the Act to cover public employees.

Notable advances have also been made in machines available and methods followed in accounting, billing and collection as well as in public relations in the water field.

The general advance made in the water works field during the time the Missouri Valley Section has been in existence, has been both substantial and helpful and both the section and the parent association may well be proud of the part they have played in securing better planning, designing, construction, maintenance and operation of water systems with the resultant improved service that has been rendered the consumers. With the spirit for service that is at present so evident in the water industry, one may feel confident that the future will see a continuance of advances toward the goal of a thoroughly adequate, satisfactory water supply being continuously delivered to all water consumers in all communities and at a cost as low as is consistent with maintaining a high service standard.

Lime Recovery From Water Softening Sludges

By Howard J. Sowden

AN IMPORTANT problem in large water softening plants is the disposal of the huge quantities of sludge which result from chemical treatment. In the 120-m.g.d. Minneapolis water softening plant, which will be ready for operation this spring, about 90 tons of solids per day will yield from the approximately 40 tons of lime per day to be used. Calcination of this sludge for the recovery of lime has suggested itself as a solution to the problem of disposal that will come with the beginning of operations. It is the experimental work in connection with this calcination of sludge and its use as a softening agent, together with the description of a simple method of determining the percentage of solids in the sludge, that will be discussed in this paper.

Water softening experiments in Minneapolis were inaugurated in 1932. These first tests were made on the conventional type plant and were designed to discover its efficacy in relation to the local water. Then, in 1937, experimentation on the Spaulding precipitator began. The experiments on this type unit are still in progress and are now being run on a unit, including precipitator, carbonation chamber, coagulation basin and sand filter, rated at a capacity of 16,000 g.p.d., and reproducing insofar as practicable the detention times and velocities of the full-size operating units. This experimental unit is designed to provide the necessary flexibility, in the application of the different chemicals, and the sequence of flow that will be required to treat highly colored water when decolorizing treatment precedes softening.

On the basis of experiments it is planned to permit alum floc to settle out in the present coagulation basins before the water is carried

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A paper presented on November 7, 1940, at the Minnesota Section Meeting, St. Paul, Minn., by Howard J. Sowden, Jr. Chemist, Minneapolis Water Department, Minneapolis, Minn.

to the precipitator for softening when the alum treatment for color removal before softening becomes necessary. Also the possibility of removing color by super-chlorination is being investigated.

Results of Experiments

As was expected, the experiments showed that a better lime can be recovered from the sludge when lime or lime and soda ash alone are used in the precipitator. Coagulants, such as iron or aluminum salts, when used with the lime, were shown to interfere with the dewatering of the sludge on a vacuum filter and to add an undesirable inert material to the final product.

The volume of sludge drained from the precipitator varied between $1\frac{1}{2}$ and 6 per cent of the water treated. When a coagulant was used in the precipitator, the volume of sludge drawn off constantly approached the 6-per cent figure. The sludge resulting from the use of a coagulant was more bulky, more slimy and filtered less readily on the vacuum filter; and it has not been possible to obtain a moisture content of less than 55 per cent when passing it through the filter. At times, when no coagulant was used in the precipitator, the sludge was definitely crystalline in character; and with this, the vacuum filter readily reduced moisture content to 40 per cent.

When 0.25 g.p.g. of ferrous sulfate was used in the precipitator, the resulting sludge yielded an average of 565 lb. of sludge cake per square foot of vacuum filter surface per 24 hr.; and when no coagulant was used in the precipitator, the vacuum filter, under the same conditions, yielded an average of 2,010 lb. per sq. ft. per 24 hr. (Table 1).

It was further observed that a filter cake with a lower moisture content was obtained when calcium oxide, in the amount of 5 per cent total solids, was added to the sludge before filtering. Apparently the added lime caused the colloidal particles of calcium carbonate to agglomerate. An attempt to condition the sludge with powdered coal, carbon dioxide, Bentonite, and heat did not improve its filtrability on the vacuum filter. In this connection, a number of filter cloths, such as 8 oz. canvas and .078 drill, were tried. The 150-weight twill proved most satisfactory in wearing and filtering qualities.

As was mentioned previously, the quantities of sludge will be so great that the problem of disposal will be of major importance. The discharge of so much sludge into the river would be objectionable. Also, the available areas for the dumping or disposal are definitely limited, at present consisting of twenty acres which will serve for

about four years. Since the sludge consists chiefly of calcium carbonate, the calcium oxide can be recovered by calcination, such recovery solving the problem of sludge disposal and, at the same time, offering a source of lime for the softening process.

If calcium oxide can be reclaimed from the sludge economically and if it proves itself wholly satisfactory as a softening agent, a saving

TABLE 1

Data on Vacuum Filter Operation

MOISTURE OF SLUDGE BEFORE FILTERING	FILTER CAKE		FILTER DRUM SPEED
	Moisture	Dry Solids	
Experiment 2—0.25 g.p.g. Ferrous Sulfate			
%	%	*lb. per sq. ft. per 24 hr.*	*rev. per hr.*
80	59.12	803	34.3
81.7	60.32	468	31.4
78.5	63.95	690	36.2
82.0	63.9	537	30.0
81.0	61.87	583	27.8
75.3	59.62	803	31.4
84.6	60.88	439	34.3
81.5	61.3	584	31.4
83.45	59.65	376	27.8
82.6	60.71	368	26.7
Experiment 3—No Coagulant			
69.6	43.3	1615	20.3
70.0	51.67	1100	26.7
61.5	41.21	2350	48.0
64.4	39.67	1950	45.0
65.0	38.34	1885	45.0
61.8	44.17	1880	48.0
62.0	37.58	2360	48.0
57.7	40.87	2940	48.0

will accrue not only in the purchase of commercial lime, but also in eliminating the cost of disposal. The experimental work performed indicates that the process offers great possibilities. Calculations made from data obtained from the experimental plant indicate that the sludge can be calcined at a price less than the present cost of commercial lime, which at the prevailing price, delivered to the St. Paul Water Department, is \$7.34 per ton.

Four experiments on the calcination process have been completed; and a fifth is in progress. Table 2 records the results of three of these experiments.

During Experiment A, the available calcium oxide dropped after each burning or cycle from 92.3 to 62 per cent after the third cycle. This decrease may be attributed to the increase of magnesium oxide, ferric oxide, and of some inert material which was present in the

TABLE 2

Lime Analyses in Calcination Experiments

CYCLE	TYPE OF LIME	TOTAL CaO	MgO	INERTS	AVAILABLE CaO
	Series A				
		%	%	%	%
First	Hydrated	97.0	1.2	1.8	92.3
Second	1st Calcination	85.6	8.7	11.6	73.0
Third	2nd "	75.7	13.0	10.3	62.0
	Series B				
First	Coml. CaO	96.0	1.2	1.4	92.8
Second	1st Calcination	88.6	6.7	4.5	80.7
Third	2nd "	82.7	10.3	6.8	70.5
Fourth	3rd "	78.7	13.0	7.3	67.4
Fifth	4th "	78.2	14.9	7.6	64.5
Sixth	5th "	72.6	19.3	8.1	62.2
	Series C				
First	Coml. CaO	95.8	2.9	2.5	90.7
Second	1st Calcination	91.6	4.9	4.2	86.3
Third	2nd "	90.2	6.1	4.6	84.3
Fourth	3rd "	91.1	5.5	2.8	87.4
Fifth	4th "	92.3	5.2	2.4	87.3
Sixth	5th "	95.2	2.9	1.2	92.9
Seventh	6th "	96.7	4.1	0.9	94.5

water originally. The iron content was due principally to the addition of 1.0 g.p.g. ferrous sulfate as a coagulant.

In Experiment B, the decrease of available calcium oxide was much less marked, requiring five burnings to drop to as low a value as was reached in Experiment A after only two calcinations. The slower accumulation of magnesium oxide and inerts was due to the smaller (0.25 g.p.g.) dose of ferrous sulfate, which permitted much of

the magnesium hydroxide to float out of the precipitator instead of trapping it as in the first case.

During Experiment C the percentage actually increased above the original content after five calcinations, after decreasing for the first two. Since conditions were kept constant, the increase can only be attributed to the use of soda ash which was added to the precipitator during the third and succeeding cycles. No coagulant was used in the precipitator during the entire experiment, thus allowing the magnesium hydroxide to float out of the precipitator and leaving behind a practically pure calcium carbonate sludge.

Before a large number of experiments have been completed, on this small scale, it is almost impossible to establish definite figures as to the amount of sludge recovered for each pound of lime used in the softening process. Figures of 1.82 lb. and 1.77 lb. were obtained in Experiments 2 and 3 (Table 3).

It is felt that the figures obtained in the experiments would be increased in actual plant practice since the turbidity in the effluent from the plant scale precipitator would be less, thereby increasing the amount of solids deposited in the precipitator. It is also reasonable to expect that the percentage loss on a large scale operation would be considerably less than that in a pilot plant scale where small quantities are handled.

Calculations made from the experimental data obtained in Experiment 3 indicate that as much lime was recovered from the sludge as was added in the softening process. This fact is brought out in Table 3, where it may, under Experiment 3, be noted that 183.3 lb. of lime was available for use in the fourth cycle, after 178.7 lb. was used in the third. Perhaps if all losses were accounted for, an excess of lime would be obtained.

The percentage recovery of available lime was calculated by dividing the available lime found by the total lime in the calcined sludge.

An effort was made to keep all conditions constant during these experiments, but this was not always possible since the chemical and physical characteristics of the raw water were changing constantly. At the beginning, total hardness was 135 p.p.m. and temperature 75°F., and by the last experiment, hardness had increased to 208 p.p.m. while the temperature had dropped to 34°F.

The sludge as it came from the precipitator contained from 2 to 5 per cent solids. The sludge was then further concentrated by natural

subsidence and by mechanical means, in a circular concentrator tank, to from 20 to 30 per cent solids. It was then applied to the 1 x 1-foot Oliver Experimental Vacuum Filter, where it was further concentrated to from 30 to 60 per cent. The sludge cake was then dried by exposure to circulating air to about 10 per cent moisture. After this it was calcined in a muffle furnace at 2,000°F. until, in

TABLE 3

Lime Recovery

CYCLE	SiO_2	R_2O_3	TOTAL CaO	MgO	AVAILABLE CaO	RECOVERY	AVAILABLE LIME AT START	SLAKER CHARGE WEIGHT	ESTIMATED DEWATERED SLUDGE PRODUCED	RETURN DEWATERED SLUDGE (LB.) / LIME ADDED (LB.)
Experiment 2										
	%	%	%	%	%	%	*lb.*	*lb.*	*lb.*	*lb.*
1*	0.5	0.9	96.0	1.23	92.8	96.0				
2	1.0	3.5	88.6	6.74	80.7	91.0	183.25	181.4	339.3	1.87
3	0.8	6.0	82.7	10.32	70.5	85.0	181.5	177.3	315.0	1.77
4	0.9	6.4	78.7	12.96	67.4	86.0	181.25	162.5	289.7	1.78
5	0.5	7.1	78.2	14.88	64.5	82.5	143.75	44.0	82.0	1.86
6	0.5	7.6	72.6	19.33	62.15	86.0				
Average						86.1				1.82
Experiment 3										
1*	1.0	1.5	95.8	2.86	90.66	94.7	205.5	205.5	387.8	1.91
2	1.2	3.0	91.6	4.9	86.7	93.4	204.5	194.1	345.5	1.81
3	0.8	3.8	90.2	6.1	84.3	95.7	191.5	178.7	315.6	1.79
4	0.6	2.2	91.1	5.5	87.1	95.0	183.3	182.4	285.4	1.56
5	0.4	2.0	92.3	5.2	87.5	94.8	162.0	163.1	289.8	1.77
6	0.2	1.0	95.2	2.9	92.9	97.5	163.6	150.8	273.0	1.81
7	0.4	0.9	96.7	2.0	94.6	98.0				
Average						95.3				1.77

* In each experiment commercial lime was used in the first cycle.

from 2 to 3 hr., tests showed it to be completely burned. The calcined material was collected and stored in tightly covered cans, and, before it was used in the softening process, composite samples were subjected to chemical analysis.

The lime was slaked in a 20-gallon container, then poured into a mechanical feeding device and fed as a suspension. The water used

for slaking was heated to at least 185°F. before the introduction of the lime.

Determination of Percentage of Solids

To provide a rapid and accurate means of obtaining the percentage of solids from the precipitator and concentrator, the following method was developed:

A special volumetric flask of approximately 500 ml. was secured and provided with a perforated stopper (Fig. 1). A representative sample of the sludge was then collected and weighed on a balance to an accuracy of one-half gram. The following formula was then derived.

FIG. 1

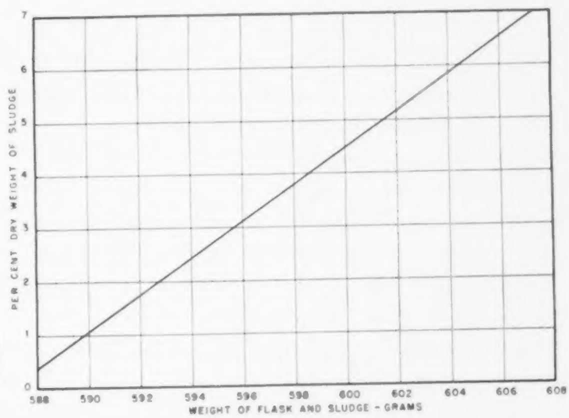

FIG. 2

FIG. 1. Constant Volume Flask
FIG. 2. Relation Between Per Cent Solids and Weight of Flask Plus Sludge

Let A = weight of flask + sludge
B = weight of flask filled with water
D = increase in weight due to the sludge
X = actual dry weight of sludge
Y = specific gravity of sludge
Z = weight of volume of water the flask will contain.

Then $D = A - B$

also

$$D = X - \frac{X}{Y}$$

and

$$\% \text{ solids} = \frac{X}{X + Z - \frac{X}{Y}} \times 100$$

The formula can be refined further to take temperature into account but as it stands it is accurate enough for all practical purposes.

By assuming a number of weights for D, the values were plotted on a graph (Fig. 2). It was then a simple matter to obtain a sample of sludge, weigh it, and read the per cent solids directly from the graph.

Conclusions

On the basis of these various experiments, then, it has been found that:

1. A chemically satisfactory calcium oxide can be recovered from the sludge of a lime and soda ash softening process.
2. When no coagulants are used in the precipitator a higher quality lime will be obtained.
3. The amounts of lime recovered on a large scale project should exceed the amounts used in the softening process.
4. The economic feasibility of recovering lime is determined by three factors: the cost of new lime, the cost of calcination, and the cost of disposal of the sludge.
5. Unusually high disposal costs may make necessary calcination of the sludge.

The author wishes to express his appreciation to A. C. Janzig and F. X. Raab, senior chemists of the department, for their co-operation in arranging the data and in preparing this article; and also to acknowledge the advice of A. F. Mellen, Superintendent of Filtration and C. C. Wilbur, Consulting Engineer.

Pipe Laying Costs of the East Bay Municipal Utility District

By Louis L. Farrell

DURING the past year, the East Bay Municipal Utility District undertook the compilation of the costs of pipe laying in its system. Such a study is, of course, influenced by a number of variable factors which tend to make comparisons difficult; so, to arrive at some valid basis of comparison, the investigation was projected to deal exclusively with cast-iron pipe laid in streets paved with oiled macadam, and to consider only the three most common sizes (4-, 6- and 8-inch) of pipe found in distribution systems. Information on the study, together with a description of the details of the cost system employed, are presented here.

The District employs eight crews of men to install new pipe line extensions and to renew old lines. Each crew is under the direction of a foreman and is a complete unit within itself. These crews are equipped with portable air compressors mounted on pneumatic tires, tool wagons, dump truck and covered service truck designed to carry small tools and other necessary material, as well as the personnel which varies in number from ten to twenty men, depending on the size of pipe and length of line to be installed.

Daily time sheets (Fig. 1) for all labor are made out in triplicate by the foreman. Included in the reports are records of the type of work in which each man was engaged, the number of hours worked, the type of equipment used and the number of hours for which each type of equipment was used. Each day these reports are turned in to the superintendent's office, where the data are checked and the extra copies routed, one to the auditing department and the other to the timekeeping division.

A paper presented on October 24, 1940, at the California Section Meeting, Los Angeles, by Louis L. Farrell, Superintendent of Construction and Maintenance, East Bay Municipal Utility District, Oakland, Calif.

A field clerk, who usually has several pipe line jobs assigned to him, draws up the location of the pipe and its appurtenances, with reference to street intersections and other landmarks, for the distribution system records. He also turns in a daily report of the

EAST BAY MUNICIPAL UTILITY DISTRICT
DAILY TIME SHEET

PLACE Oakland

TIME July 1, 1940

ORDER TO BE CHARGED ✓ KIND	NUMBER	77 Perreira Jas.	109 Stevens B.M.	170 Tocchini A.	232 Lewis L.	247 Burke Pat	249 Breunig J.A.	257 Sando Tony	270 Costa J.	273 Smith C.A.	365 McGee Wm.	463 Pilotti A.	838 Hinkson J.N.		627 Turpen O.S.			TOTAL HOURS	AMOUNT
E	22625																		
	Labor Segregation Code Numbers 1	8	8	8														24	
	4				8	8	8	8	6	6								44	
	5								2	2								4	
	9										8	4	4					16	
	10											2						2	
	11											2	2					4	
	12														8			8	
	15												2					2	
		8	8	8	8	8	8	8	8	8	8	8	8		8			104	

EQUIPMENT	NO.	HOURS	ORDER	NUMBER	OPERATOR
Trencher	3	8	E	22625	B.M. Stevens
Compressor	5	8	E	22625	A. Tocchini
Tractor	8	4	E	22625	J.N. Hinkson
Pick-up	389	2	E	22625	J.N. Hinkson
" "	"	6	"	"	O.S. Turpen

CORRECT A. P. Trawick

CORRECT Chas. E. Jones

APPROVED E. P. Johnson

FIG. 1. Daily Time Sheet

number of feet of trench excavated and the number of feet of pipe laid. Progress cost reports are prepared on the larger pipe installations and new structures. In addition to the work mentioned, the field clerks are provided with soil resistant recording equipment for making soil tests for the electrolysis investigation committee;

and it is their job as well to keep a check on the amount of material ordered out on the job, the amount of material used, and the amount to be returned.

Conditions Determining Costs

Costs are largely a question of conditions and locations, varying tremendously from a level straight street to a hillside where every length of pipe stands at a 45-degree angle, or from a new subdivision without pavement or traffic to a congested area where every conceivable underground structure as well as present day traffic conditions must be encountered. Another factor entering into cost is

TABLE 1

Installation Cost on 6-Inch Cast-Iron Pipe, Under Oil Macadam Pavement, and Average Man-Hour Rate

June 30, 1934 to June 30, 1940

FISCAL YEAR	LIN. FEET INSTALLED	AVERAGE MAN HOUR RATE	COST PER LINEAR FOOT				
			Labor	Material	Paving	Overhead	Total
1934–35	53,132	.5593	.5922	.8946	.1739	.2846	1.9453
1935–36	42,447	.6336	.6017	.8697	.1621	.2853	1.9188
1936–37	58,021	.6646	.7477	.9228	.1590	.2770	2.1065
1937–38	57,941	.7183	.7541	.9614	.1413	.2404	2.0972
1938–39	45,807	.7219	.7626	1.0566	.1653	.2885	2.2730
1939–40	78,709	.7232	.7342	.9828	.1759	.3978	2.2907

Note: 1934-35 Labor cost excludes 56,000 ft. of 6-inch cast-iron pipe in Orinda on which labor costs ran about 30¢ per foot, and which would bring average for year to 45¢ per foot for labor.

the soil condition. Everything from quicksand to blue trap rock, with black adobe predominating, is to be found in the area and the difference in handling each type has a material effect on cost figures. See Table 1 for installation costs during the past six years.

The policy of the District in extending an existing main for a distance of 150 ft. without charge for each additional service is largely responsible for an increased cost; as many owners, in piping their holdings, take advantage of this policy rather than paying outright for the extension and later receiving a refund. In such cases owners apply for a service 150 ft. away from an existing main; then, shortly after completion of the job, apply for another such extension, and do this until their property has been piped with no

outlay of money on their own part. The technique is, of course, expensive to the department in that it requires a great amount of wasteful moving and setting up of equipment for a number of small and, therefore, uneconomical jobs.

Although seven trenching machines, cutting trenches from 15 to 54 in. wide and from 5 to 15 ft. in depth, are operated, many of the shorter extensions are hand excavated due to inaccessibility. In many cases, too, the extensions are so short that the transportation of a machine is not warranted.

Both maintenance and construction work are constant rather than seasonal. Consequently, there is considerable difference in cost per foot at various times of the year (Fig. 2), costs during the

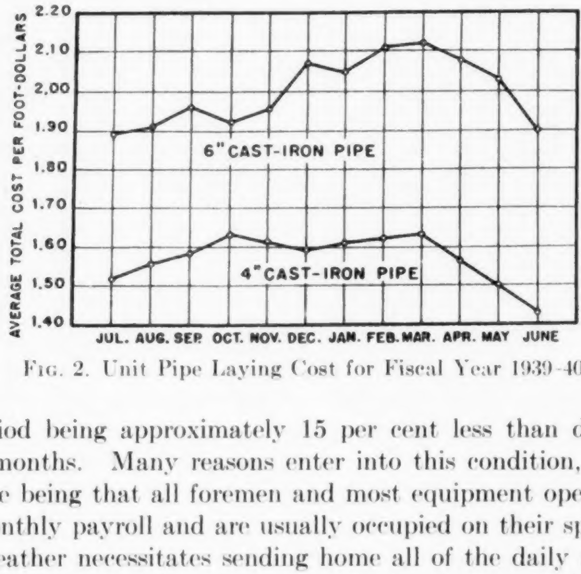

FIG. 2. Unit Pipe Laying Cost for Fiscal Year 1939-40

dry period being approximately 15 per cent less than during the winter months. Many reasons enter into this condition, the principal one being that all foremen and most equipment operators are on a monthly payroll and are usually occupied on their special jobs when weather necessitates sending home all of the daily men for a few hours or a few days. As a general rule, the pay of the salaried men is charged to any extension upon which they may be working.

Twice monthly a report showing labor, material, equipment and total cost data on all the pipe installed under the direction of each foreman is prepared and posted, in graph form (Figs. 3 and 4), in the Corporation Yard Office. The graphs, showing comparative data both for the current month and cumulatively from January 1, 1939, when the record originated, help give the foremen an idea of how

their work compares with that of others on similar jobs and serve to develop a spirit of good-natured rivalry among them.

Recently, due to numerous requests from organized labor, and in view of the fact that very few of its employees are affiliated with any labor organization, the District agreed to contract a limited number of extensions. So far, about 7,146 ft. of main in sizes from 6 to 36 in. have been contracted. The first public contracts were bid very much under the District's average cost and considerable difficulties were encountered in compelling the contractor to live up to specifications. Subsequent bids have been more comparable

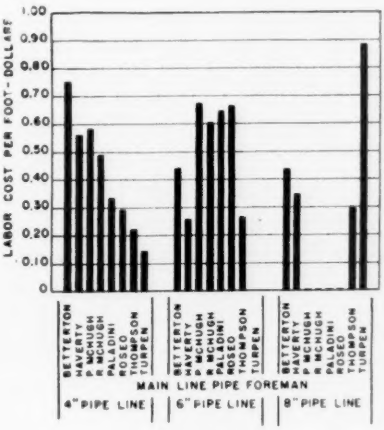

FIG. 3

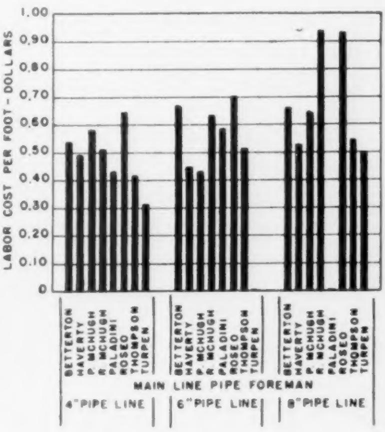

FIG. 4

FIG. 3. Unit Pipe Laying Costs by Foremen for August, 1940
FIG. 4. Unit Pipe Laying Costs by Foremen, January 1, 1939, to September 1, 1940

to the costs incurred by the District's own crews. While the work has been acceptable in a general way, the department is very frank in believing that a much more workmanlike job is obtained with its own forces.

Comparison of Costs

In considering comparisons in cost between those of the regular forces and a contractor's cost, many conditions, which should permit the contractor to install work at a considerable saving, exist. For example, on all work of this nature the department men, who are

permanent employees, arrive on the job at 8 A.M., or leave the Corporation Yard with District transportation in time to start work at 8 A.M., and are permitted to leave the job in time to be in the Yard by 4:30 P.M. Contractors working under the same conditions would have their men report on the job at 8 A.M. and work until 5 P.M., a full eight hours, and would not be concerned with any transportation problems. Another problem confronting the department is the necessary, but expensive, moving with a full crew from one piece of work to another. This necessity results in a condition where a job is probably over-manned on the final clean-up and over-manned for the first day on the new job. Such a condition would not, or should not, exist on an efficient contractor's job. He could organize with a small crew and increase his man power as the job progressed, also decreasing it materially as the job neared completion.

Cleaning Mains at Manasquan, N. J.

By J. K. Van Brunt

THE quantity of water that may be conveyed through any pipe line is dependent on a number of variables, the first of which is velocity of flow. Velocity in turn is derived from the available pressure head impressed on the pipe line. Further, the velocity of flow is retarded by friction. Frictional resistance offered to the flow is in direct relation to the quantity and to the condition of the interior pipe walls.

In short, suffice it to say that, everything else being equal, less horsepower is required to deliver a given number of gallons of water through a pipe the walls of which are smooth and clean than would be required to convey the same quantity through a line which is badly tuberculated.

The tolls paid to incrustation and tuberculation of water mains in increased pumping costs are not always apparent. The following simple example will serve to indicate the extent these losses may assume.

Assume an 8-inch pipe delivering $1\frac{1}{2}$ m.g.d., with a Williams-Hazen coefficient of 140, and for new pipe the power required to overcome pipe friction alone per 1,000 ft. is approximately 4.5 h.p. With the coefficient reduced to 80, however, the power required becomes 12.8 h.p., an increase of 8.3 h.p., which amount, of course, is creditable to the resistance to flow offered by the tuberculated condition of the pipe interior.

The importance of maintaining pipe walls in a smooth clean condition is obvious both from the standpoint of adequate volume and pressure for fire flow demands as well as economy in pumping operations. Many methods have been tried to accomplish this result,

A paper presented on May 22, 1940, at the New Jersey Section Meeting at Trenton, N. J., by J. K. Van Brunt, Borough Superintendent, Manasquan, N. J.

among which is a device and method developed for mechanically cleaning the interior pipe walls of water mains in place.

Experiment in Borough of Manasquan

Last year the Borough of Manasquan completed a main cleaning program in three sections of the distribution systems as an experiment in order to determine the effectiveness of main restoration by this method.

The Manasquan supply is derived from shallow wells which produce a water characterized by a high carbon dioxide content, low pH and alkalinity; thus it is quite aggressive to ferrous pipe. Aeration is the extent of treatment at the present time.

Fig. 1. Typical Section of Pipe; diameter of which has been reduced by iron corrosion

From the nature of the incrustation precipitated on the pipe walls it was felt that it would be quite readily removed by the cleaning mechanism. The extent to which the "build up" had advanced in these lines was apparent from the cross-section of an 8-inch test piece removed. The area had been reduced to the equivalent of a $6\frac{1}{2}$-inch opening (see Fig. 1).

The sections cleaned comprised a total distance of 1.91 mi. of 8- and 6-inch cast-iron mains. The 8-inch pipe was cleaned with a so-called pressure machine for which water pressure is used to drive it through the pipe. This machine is about 6 ft. in length, composed of a series of 6 cutting heads and two driving pistons (see Fig. 2). Each cutting

head is provided with a number of spring steel cutting blades secured around the circumference.

The two flexible pistons from which the machine gets its drive are provided with adjustable openings regulating the speed of travel and the quantity of water passing the equipment to carry, ahead of the machine, debris removed from the pipe. In an exceptionally dirty pipe line, the ports in the driving pistons are practically closed, giving added drive and of course allowing very little wash water to pass. In this case the machine moves through the pipe line very slowly.

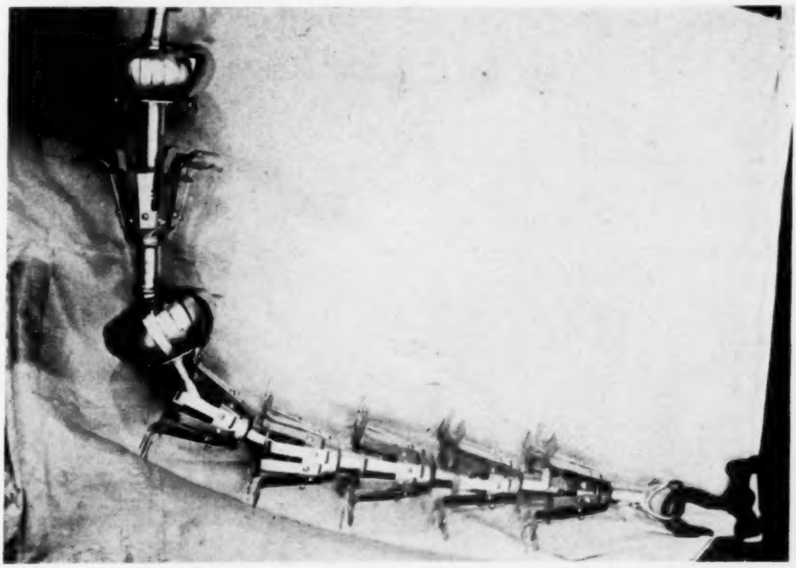

FIG. 2. Illustration of Flexibility of 8-Inch Cleaner

Under usual conditions the rate of travel is about 70 to 100 ft. per min.

The pistons and cutting heads are mounted on a vertebral spring and flexible cable, the flexibility permitting the machine to negotiate a standard 90-degree bend without difficulty. As a matter of experience, in one section of Manasquan 8-inch main, passing under a creek, the machine negotiated four 45-degree bends without hesitation. Contrary to popular notion the machine has no spiral or rotary motion but depends entirely for its cleaning operation on a scraping action of the cutting blades under severe tension.

Preparing the Main for Cleaning

Preparation of the pipe line for the cleaning operation is carried out in a systematic and expeditious manner. Not the least important of the preparations is notifying all consumers in the section affected, well in advance of the work to be done, and telling them how long the service will be off.

On the Manasquan project, the exact location of intersecting fittings was determined by the M-scope. Four cuts of approximately

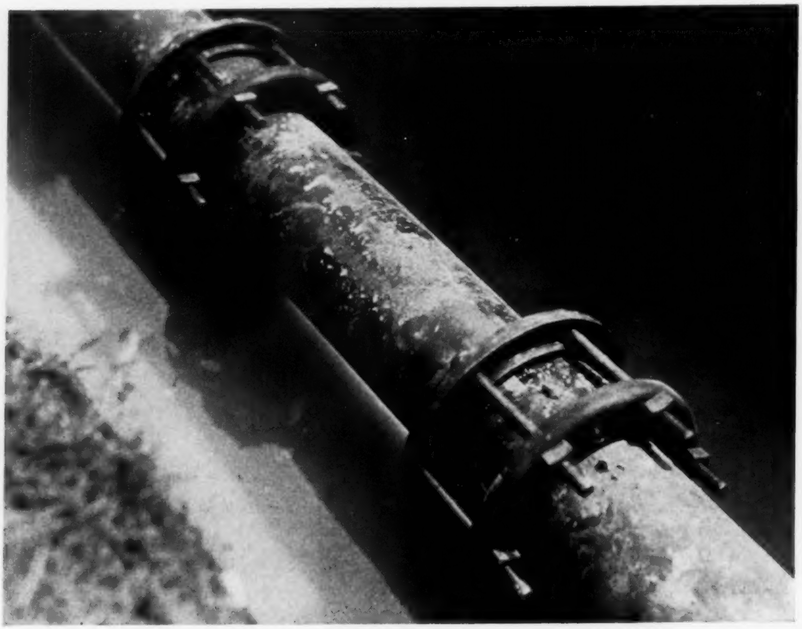

FIG. 3. Cleaning Machine Has Been Inserted; Pipe has been made up with Dresser couplings and is ready for the "shot"

32 sq.ft. each were necessary in concrete paving to provide ample working space for inserting and extracting the cleaning mechanism. In order to save time and facilitate the operation of getting the machine in place, it is often found advantageous to cut a section of pipe long enough to accommodate the cleaner and to jack the machine into this section of pipe as an advance preparation. By this method, when everything else is in readiness, a section of the line to be cleaned is removed and the length of pipe with the machine in place is permanently jointed either by solid or Dresser sleeves (Fig. 3). At the

end of the section to be cleaned the pipe is again cut and a temporary riser line rigged to carry the debris and wash water out of the trench. This is usually accomplished by a 45-degree fitting and a short length of pipe.

The pipe is now ready to be cleaned. The gate on the main is opened slowly until the machine begins to move. Generally the progress of the cleaner through the line is audible at the surface or at least when passing gate valves. Water issuing from the riser pipe will assume a dirty brown appearance until the machine approaches the end of the run, when the water becomes thick and black and

FIG. 4. Machine Traveling Under Water Pressure Has Removed This Incrustation

finally the solid material issues from the riser pipe like sausage. In the case of one shot of 1,850 ft. of 8-inch pipe, there were about 3 cu.yd. of solid material cleaned from the line (see Figs. 4 and 5).

After the machine has reached its destination, the main is thoroughly flushed, the riser pipe is dismantled, and the main reconnected and placed in service.

It might be of interest to note the length of line that may be cleaned in one set-up: A section of 8-inch main, 1.31 mi. in length, which is a main feeder to a beach area was cleaned in one "shot." In this section the cleaning mechanism was required to pass through the following fittings: 8 gate valves, 25 tees, and 4 45-degree

fittings. The total time required for the machine to travel this distance was 70 min. In working on this length of line, men were stationed at each hydrant along the entire length. As the machine approached, the hydrants were opened, flushing out large quantities of debris and thus relieving the load ahead of the machine and at the same time speeding up the process.

Method for Cleaning Small Mains

The method used to clean 6-inch and smaller mains differs somewhat from the pressure method described above. The section to be cleaned is isolated or valved off and sections of the line removed

FIG. 5. Cleaning up Incrustation Removed From Main, Manasquan, N. J.

at both ends. A light cable is attached to a "carrier" and started into the line. The "carrier" is a short rod to which are attached two leather pistons. The main is joined at this point by means of a special make-up coupling through which the cable is fed. The gate is opened and the carrier is shot to the end of the line, thus pulling the cable into the pipe. This small cable is then used to pull a heavy cable back to the starting point; and the cleaning tool is attached to the heavy cable. The pipe line is then permanently reconnected and the gate opened to provide wash water. The cleaning tool, which is somewhat similar to the pressure machine but without the driving power, is pulled through by a gasoline-engine-driven winch. Such equipment is shown in Fig. 6.

This method is somewhat slower than the pressure method and care must be exercised to avoid breaking the cable and losing the tool in the line. The thoroughness of cleaning, however, is undoubtedly equal to that for larger mains cleaned by the water driven mechanism.

In pressure cleaning the drive of the machine is dependent upon the water pressure acting on the pistons. One section of 8-inch pipe cleaned was a trunk line without hydrants to blow off the debris

FIG. 6. A Machine Being Pulled Through Main With Cable and Windlass

ahead of the machine. In this instance some difficulty was experienced in keeping the machine moving because of accumulated material fouling the cleaner. It was found necessary to increase the pressure above the normal line pressure in order to force the machine.

It is recommended that the curb stop on each house connection be closed before the cleaning operation is started to prevent the material from entering the house plumbing. On this job, however, in view of the number of connections and the work involved in

locating and shutting off each individual house service, it was decided to trust to luck. When the cleaning was completed and the water again turned into the line, about 10 per cent of the service lines were completely plugged up. In those cases the lines were disconnected in the basement and pumped back into the main by the aid of a hand force pump. No trouble of this nature was experienced on the section of 6-inch cleaned by the drag method, probably because of an abundance of wash water.

As the machine progresses through the line, hydrants are opened to flush out the debris. In the mile and a quarter stretch, two 4-inch hydrant branches were completely filled. It required the use of a fire department pumper to dislodge the stoppage and free the hydrant. This difficulty was caused, no doubt, by closing the hydrant too soon after the machine had passed the branch. The hydrant must, of course, be closed soon after the machine passes to keep pressure on it.

Little or no difficulty was experienced from poor joints, gate valves or fittings which might have caused the machine to "hang up." Once started the machine progressed through the line at a surprising rate of speed.

In the writer's opinion the difficulties encountered were many times offset by the good that was accomplished in the cleaning work.

Results of Flow Tests

In order to determine as accurately as possible the effectiveness of the cleaning operation, a 200-foot section of the 8-inch line was isolated as a test section before cleaning. Pitometer tests were made, from which data, determinations of the value of C in the Williams-Hazen formula were made.

The results of these determinations indicated that the frictional coefficient had been reduced to 80 on 8-inch Class D cast-iron pipe laid in 1903 and in continuous service to date. The value of C determined in the same manner on this section after cleaning was found to have increased to 139. In other words, the cleaning operation was effective in restoring the pipe line to practically its original carrying capacity.

Further, before-and-after hydrant flow tests in the same locations indicated the following increases: in the mercantile district, an increase of 38 per cent; in the beach area, an increase of 85 per cent; these at 20 lb. per sq.in. residual pressure.

Costs and Conclusions

No attempt has been made to break down the costs on the various sections cleaned. The work involved 8,666 ft. of 8-inch and 1,320 ft. of 6-inch or in round figures a total of 10,000 ft. at a cost of $1,500 which included the actual cleaning plus all labor, fittings, rental of an air compressor and restoration of paving. The unit cost was 15 cents per foot.

All lines were under concrete pavement. The reader may judge the costs involved had it been necessary to replace these lines.

In the writer's opinion water main cleaning has accomplished a great deal as far as it has been carried in the Borough of Manasquan. An inspection of the pipe before and after cleaning shows clearly how thoroughly the incrustation has been removed without any apparent damage to the original lining.

The advisability of cleaning pipe lines in a water system smaller than 6 in. in size is questionable. The writer feels, however, that much may be accomplished in the way of restoring lines of larger sizes to good condition at little cost by this method.

The length of time cleaned lines remain in that condition is, of course, another question. It is maintained by some that tuberculation begins all over again and no doubt it does, unless adequate treatment is applied and maintained.

We are satisfied, however, that fire flows have been greatly increased; consumers have commented on the increased pressure whether real or imaginary. Hydrants that were weak are again gushing forth with renewed energy. Operators of water systems whose supply or method of treatment is such that tuberculation of the lines does not create a problem are indeed fortunate. For superintendents confronted with the question of what to do about restoring lines that no longer meet requirements for which they were designed, the writer believes water main cleaning worthy of investigation.

Lowering Cast-Iron Mains Under Pressure

By Harold L. Crane

A DETAILED account of the lowering of cast-iron pipes under pressure will first be given as an outline of the operation as a whole, and then the author will cover several additional points which he has found important. In this outline an effort has been made to cover all situations which may arise in such operations.

As the reader may have guessed, the operation is a rare one, for there are only a few reasons why, or occasions when, it would be necessary to resort to it.

If it is at all convenient, the pressure should be turned off when the pipe is being lowered, but often or, in fact, usually, the pipe with which one must work supplies a town. Shutting it off, therefore, would entail considerable inconvenience; and fire hazards might even make it impracticable.

The situations that would force one to lower the pipe are also few in number, the most common being where a pipe is exposed or left with so little cover, e.g. from the regrading of a road, as to be unsafe, and must be lowered enough to make it safe from mechanical shocks. Such a grading may be only a slight one, but one which is necessary to get it below the frost line. A second situation is that when a new sewer line or culvert crosses the water pipes. As the sewer line must be laid to an established grade, it is usually given the right of way so the water pipe must be lowered.

Let us assume that such a situation has arisen. In starting the job, the lowest point on which the pipe will finally rest must be determined. It is obvious that this depth is merely the depth of the grading or the necessary amount to allow the sewer's clearance, as the case may be.

A paper presented on October 19, 1940, at the New Jersey Section Meeting, Atlantic City, N. J., by Harold L. Crane, Superintendent, Elizabethtown Water Company, Consolidated, Elizabeth, N. J.

When this is done, the number of joints that must be uncovered on either side of the deepest point must be calculated. This calculation has been facilitated by the use of a chart such as Fig. 1.

The digging must be done as deep as the lowest point and back far enough to uncover the necessary number of joints on either side of that point. The trench, when it is dug, should extend at least 2 ft. from either side of the pipe, to allow digging down on the sides and under it. In this digging, a 2-foot pier of earth, the width of the trench, should be left in back of every bell. This pier should extend

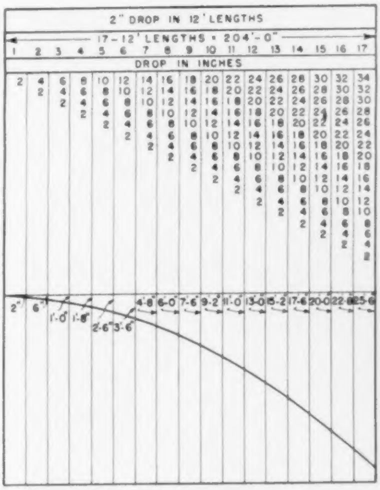

FIG. 1

FIG. 2

FIG. 1. Chart for Calculating Number of 12-Foot Lengths Necessary for Given Depth

FIG. 2. A 36-Inch Main Being Uncovered; note earthen piers by bells

halfway up the side of the pipe to prevent it from slipping. The piers will thus divide the trench into boxes about 10 ft. long that extend down to the final level (Fig. 2).

On the bottom of the trench, bell holes must be dug to allow for the calking of the joints after the main is finally lowered into the new position. This latter point is important, for without such holes, calking will be extremely difficult or impossible.

When the digging is completed, vertical blocking should be placed on either side of the pipe and in the middle of the boxes (Fig. 3). Blocking is required, since the pipe might otherwise slip to one side

during the lowering and thus cause a blowout. For a large pipe, the blocking should, of course, be heavy. The author has found that large timbers are best suited to this purpose. What has just been said applies if the pipe is straight and if it is to drop absolutely vertically. Often, however, the main is curved, and is to be straightened. In this case, blocking must be done on the outside of the curve only; and as the pipe is lowered, it will tend to straighten of its own accord.

With the trench dug, and the blocking in, the pipe is ready to be lowered. Two men are now stationed at each one of the earthen

FIG. 3

FIG. 4

FIG. 3. Vertical Blocking of 36-Inch Main
FIG. 4. Main Lowered With Blocking Removed and Calking in Progress

piers, if the pipe is large; if the pipe is small, one man may suffice. At the deepest point, which is now approximately in the middle of the length of the open trench, the men start to pick away the earthen piers alongside the pipe. The digging, at first, will naturally be done chiefly at the center, as this is the point where the pipe must be lowered most. As the center two men progress, the next two start to dig, and so on down the line. All during this work, careful watch must be kept to see that no two workers get ahead of the others. The work must frequently be stopped and the pipe sighted to see that

it is dropping satisfactorily. Also, the picking away of the piers will let earth into the bottom of the trench, and since the latter is already to the exact depth, this earth must be removed continually.

When the pipe is finally down to the bottom of the prepared trench, and in place, the joints should all be gone over with calking tools, and then inspected to see that there are no leaks (Fig. 4). After a little of the trench is refilled, the vertical blocking should be removed. The operation is then complete and the trench may be closed up.

By now, many readers may wonder why the pipe goes down at all, and why it does not come apart during the lowering. The answer to the first question is simply that often the pipe will hang in midair and it will be impossible to force it down vertically. The operation is, of course, dependent upon the lengths of pipe slipping in their joints one way or the other, as is desired. Where they have been well fitted together when they were first laid, they will not close up, and it will then be necessary to remove the blocking on one side to allow the pipe to slide to one side and then down. If there is danger of the pipe coming apart and a blowout occurring, a check must be kept to see that it does not slip out too far. The way the author has done this is to place a small mark about 3 in. from the bell face, and to check constantly as the main is being lowered to see that the pipe is not slipping out too far. In case one of the joints is coming apart more than is desired, the trouble is usually that some other part of the pipe is not being lowered proportionately. By ceasing to lower at the point that is slipping, and lowering more at some other point that is not going down as it should, the danger of a blowout may be lessened greatly. From the above, the reader may gather that the entire operation is very delicate, and that the job should be in no way rushed or carelessly done.

Experiences in Lowering Various Mains

A peculiar situation which the author encountered will illustrate some of the complications which may arise in this work. A road was being regraded, and the water pipe was not only exposed but was 4 ft. inside the edge of the proposed pavement for a distance of about 400 ft. Lowering the pipe in a vertical position here would have made it difficult to have repaired the main later, in case of a leak, when the road was completed. It was necessary, therefore, not only to move the pipe down, but also to one side. This was accomplished by digging a sloping or 45-degree trench from where the pipe lay

on the surface of the ground to a position 4 ft. over and 4 ft. down. The earthen piers were used, as in the vertical trench, but no blocking was necessary as the pipe could slide only in the desired direction. This use of gravity as a block made the work in many ways easier than the straight lowering. While only one method of lowering pipe under pressure has been described, there is another which the author has employed, and there is still a third about which he has heard but knows of no actual case where it was employed. Several times the author has been confronted with water pipe so close to a parallel gas main that he was compelled to use a cable sling around the pipe every 12 ft., and a hook made of $1\frac{1}{2}$-inch stock with about 4 ft. of thread on the shank. The shank was placed through a hole in a heavy timber laid across the trench, with a steel plate on top supporting a hexagonal nut. All of the excavating was then done on the side of the water pipe away from the gas main. By doing this, the gas main was not undermined. The lowering was then done by unscrewing the nut. This method requires considerable equipment and is expensive.

Finally, the author has heard of a method in which cakes of ice were placed under the pipe between the piers of earth. The latter were then dug away, and the pipe allowed to settle as the ice melted. There are many difficulties and flaws in this procedure, such as getting the cakes of ice large enough to support a heavy pipe, and the melting of one section of ice faster than another. Truthfully, the only apparent reason for using this last method would be if one had a friend who was an iceman and needed the business.

In conclusion, it may be said that the main requirement for the successful performance of this operation is a sound heart; for, from the moment the pipe starts to go down, your blood pressure will go up, and will become normal again only when the pipe is safely resting on the bottom of the trench.

Cement Joints for Improved Water Quality

By L. J. Alexander and R. M. Ebaugh

CONSIDERABLE interest, especially at the A. W. W. A. Convention at Kansas City, has been manifested in the making of cement joints as practiced by the Southern California Water Company. Many water works men in California and perhaps in other parts of the country, are familiar with cement joints, so we ask their forbearance, if we repeat some facts familiar to them.

This paper is not to be construed as a criticism of accepted jointing methods, but rather as a presentation of a different angle to one method which has been found to eliminate many sources of trouble.

Mechanical joints which use rubber and no jute are sometimes employed, but the element of cost seems to interfere with their wider use.

The customary jointing materials—lead, sulfur compounds, mechanical joints, and cement—vary, depending upon cost, custom, and locality.

Of all the methods and materials of jointing, lead calking is probably most commonly used. Such joints, however, present the problems of jute contamination of the water and of failure at times through vibration; and cost of material and installation labor may be relatively high.

Sulfur compounds are often substituted for lead, due to their lower cost, but, again, jute is used for packing to hold the compound and the problem of contamination from this source still remains. Sulfur compounds may also be the cause of changes in quality of water inasmuch as sulfur is a food for certain bacteria. Failures of joints have resulted because "bacteria originating in the water attacked one of the elements in the joint compound, causing exces-

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A paper presented on October 24, 1940, at the California Section Meeting, Los Angeles, by L. J. Alexander, Designing Engineer, and R. M. Ebaugh, Construction Engineer, both of the Southern California Water Co., Los Angeles.

sive leakage" (1). In Southern California there is a prevalence of iron and sulfur organisms, and this problem is constantly prominent when sulfur compounds are used as substitutes for lead. One of our 16-inch lines (2), the joints of which were made up with one of these compounds, has been a constant source of trouble. The line, 15,000 ft. long, was laid in 1928, and there have since been many leaks. All but two (breaks in the line caused by a washout during a flood) of these leaks were caused by deterioration of the compound due to bacterial action.*

The fewer the leaks the less possibility there is for contamination during repair operations. Even though each workman is aware of the hazard of contamination, elements beyond his control are always likely to lead to disastrous results. When dangers of contamination are constantly facing us, we must do all in our power to minimize or eliminate them. Water is particularly susceptible to contaminating influence. Every procedure we can adopt to safeguard the water is necessary.

The truth of the above statement was forcibly brought to the attention of the Engineering Department of the Southern California Water Company eight years ago when coliform contamination developed in a newly laid water main. For several years, all water served to this system had been treated, and at no previous time had there been coliform contamination. Furthermore, the newly laid main had been heavily chlorinated at installation, and the water supplying this main was, as shown by repeated tests, free of coliform organisms. Repeated tests of the water, after it passed through the line, showed indices of 60 plus, not once, but continuously, even after repeated chlorination of the line with doses of chlorine exceeding 1,000 p.p.m. Eventually (after 84 days) the indices became zero, but, in the meantime, the consumers on the line were subjected to a continuous chlorinous taste, about which they rightfully complained. This problem was relatively simple because the line was non-circulating. Imagine the problem, if it had occurred in a circulating line, spreading water containing coliform organisms through the entire system!

An investigation revealed that the jute used in making one joint had become badly contaminated during construction, despite all precaution taken by the foreman and calker, and had caused all the trouble. Other concerns have had similar experiences.

* Aside from areas where sulfur organisms are prevalent in the soil or water, difficulties of this type are not known to be associated with the use of plastic sulfur jointing compounds.—*Editor*.

We had previously suspected jute as being the cause of several cases of water contamination, and the particular case mentioned only emphasized the need for a different jointing material. Few substitutions have been made for jute, which "by the very nature of its curing, preparation and handling, is an impure and unclean product and could contaminate water" (3).

W. M. Rapp and Paul Weir (3) made a notable contribution to water works practice by the substitution of braided cotton yarn for jute. They proved, by extensive bacteriological examinations, that cotton yarn was not contaminated by coliform organisms.

Importance of Main Disinfection

It is admitted that sterilization of mains and of jute will often prevent dangerous contamination due to either, but the fact still remains that where coliform indices appear they must be explained. A water department treads on pretty thin ice if the sample taken from the consumer's tap has a positive coliform index, though such an index may not necessarily signify danger (4). Sterilization of jute, and sterilization of newly laid pipe, does not always prevent the appearance of a positive index. Incidentally, nothing in this paper is meant to imply that new mains should not be sterilized. The "Importance of Water Main Disinfection" (5) cannot be overstressed.

It has been claimed too that jute is the source of disagreeable odors and tastes. *It is often difficult to* convince irate consumers that there is nothing injurious to health in a water that tastes like varnish, coal oil, eucalyptus, or putty.

Our problem was solved not by a substitution for jute, but by its elimination.

Cement is used in some localities, but nearly always with jute for backing, but jute, in the writers' opinion, is as useless as the buttons on a man's coat sleeve. Eight years' experience has substantiated this opinion. Cement has long been used as a substitute for lead in pipe joints (6, 7). It is cheap and easy to use; moreover, it is permanent, probably as permanent as the pipe itself, and capable of withstanding excessive shock (8). This was proved by experience related in several papers, dealing with the effects of the Long Beach earthquake of March 10, 1933. In normal bell and spigot cast-iron pipe, it is possible to eliminate jute, or its substitute, only by the use of cement as a jointing material.

Procedure for Making Cement Joints

Accordingly, we shall outline the procedure for making these joints: The first step, an important one, is to align carefully and make sure that the spigot is driven home, also that the calking space is concentric, or nearly so. Portland cement, without sand, is mixed with just enough water to dampen it ($\frac{1}{2}$ gal. to 24 lb.) so that it will compact into a ball when squeezed, and will shatter when dropped one foot. The cement is mixed on a piece of canvas, and placed in the bell hole under the pipe joint. This mixture is tamped into the joint with a calking tool, then an ordinary calking hammer and cement calking tools are used to drive the material into place. We must emphasize that the calker must use hard blows. The joint must be dressed at least three times for 4-inch cast-iron pipe and four times for 6-inch cast-iron. The operation is repeated until the joint is calked solid. It will ring like a lead joint when properly done. The joint is finally pointed up with the fingers to a smooth surface. Twenty-four hours later the line will withstand full pressure.

One favorable feature of such joints is the cost. A joint in 6-inch pipe, for example, should not cost over 12 to 15 cents, including labor and material. A few months ago, 243 ft. of 4-inch Class 250 pipe was installed; the ditch was dug, pipe laid, calked with fast setting cement, tied in, ditch backfilled, and placed in operation by eight men in one day, with a total labor cost for this job of 24 cents per foot.

Our test requirement on cast-iron lines jointed with cement (without jute) is that leakage be zero, and our construction crews have no difficulty in meeting this requirement. In fact, if the crews have any leakage, they feel they have slighted their job, and comments from the superintendent are unnecessary.

Use of Asbestos Rope

Until recently we were still faced with the necessity of making our wet "tie-ins" with jute and lead. In these cases, the usual problems caused by jute were present, but very much minimized. Recently, we have been experimenting with asbestos rope. Bacteriological tests on this material show its advantages conclusively (9). An exhaustive series of tests on jute (9) has shown that in addition to coliform organisms the plate counts were innumerable on 24-, 48- and 96-hour tests. One test was made on a sample of jute removed from a recently laid line and the indications were that the jute was more highly contaminated than samples of new material. Asbestos

is an inert material and will not support bacterial life, nor will it produce odors or tastes in water.

Asbestos rope is considerably more expensive than jute, but considering the problems it eliminates as compared with the use of jute, it seems well worth the added expense. It is an infinitesimal additional cost compared with the total involved on new construction. We have not had sufficient time to prove this material, but from all results obtained thus far, it has great promise.

To summarize, we wanted to eliminate all possible contamination caused by jute; we wanted to eliminate the possibility of offensive odors and tastes; we wanted to eliminate food for sulfur organisms; and we wanted to keep our costs as low as possible. To do this we are using cement without backing materials on the lines and wet tie-ins with asbestos rope backing and lead.

The Standard Specifications for Laying Cast-Iron Pipe (10), adopted by the American Water Works Association in 1938, include (Sec. 10. Jointing Pipe) cement as one of the approved materials. Subsections 10.31, 10.61-66 and 15.32 outline specifically the approved method for making cement joints and testing them after they are completed.—*Editor*.

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9. Wilson, Carl. Communication Containing Results of Bacteriological Analysis on Jute and Asbestos Rope. (*Unpublished.*)
10. Standard Specifications for Laying Cast-Iron Pipe. (Adopted April 28, 1938.) Published by the American Water Works Association.

Report of the Audit of Association Funds For Year Ending December 31, 1940

To the Members of the American Water Works Association:

The By-Laws require that the Secretary shall have made an annual audit of the books of the Association.

The records for 1940 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Reference may be made to past audits which appeared as follows: for 1937, on pages 520–25 of the March, 1938, JOURNAL; for 1938, on pages 570–74 of the March, 1939, JOURNAL; and for 1939, on pages 516–20 of the March, 1940, JOURNAL.

There is also submitted a membership statement for 1940 and a comparative record for 1931–40 inclusive.

Respectfully submitted,

HARRY E. JORDAN, *Secretary*

February 20, 1941

Mr. Harry E. Jordan, Secretary
American Water Works Association
22 East 40th Street
New York City

DEAR SIR:

As a result of our examination of the books of account of your Association for the year ended December 31, 1940, the following described exhibits and schedule are submitted:

Exhibit A—Balance Sheet, December 31, 1940
Schedule 1—Investments, December 31, 1940
Exhibit B—Statement of Income and Expenses for the Year Ended December 31, 1940
Exhibit C—Surplus Account for the Year Ended December 31, 1940

In accordance with the practice established in prior years, appropriate accruals for receivable and payable items are reflected in the accompanying statements.

In our opinion, the accompanying balance sheet and related statements of income and expenses and surplus fairly present the position of the American Water Works Association at December 31, 1940 and the results of its operations for the calendar year in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Very truly yours,

LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—Balance Sheet, December 31, 1940

Assets

Cash in Banks and on Hand			$32,377.71*
Deposit—United Air Lines			425.00
Accounts Receivable:			
Advertising		$1,947.50	
American Public Health Association		1,187.22	
Reprints		392.34	
Sundry publications		648.30	4,175.36
Membership Dues			336.83
Accrued Interest on Bonds			241.04
Inventories:			
Type metal		$289.70	
Cumulative Index (606 copies)		727.20	
Manual of Water Quality and Treatment (140 copies)		280.00	
Manual of Water Works Accounting (25 copies)		36.25	
Sundry publications		528.99	
Membership certificates		21.15	
Fuller Memorial Award certificates		69.00	
Back issues—Journal—Vols. 1 to 32, inclusive (21,672 copies)		—†	
Back issues—Proceedings—1881 to 1913, inclusive (497 copies)		—†	1,952.29
Office Equipment:			
Depreciated balance, January 1, 1940	$3,707.57		
Net additions for year 1940	596.66	$4,304.23	
Less: Depreciation for 1940		476.19	3,828.04
Investments, per Schedule 1:			
Investments, at cost		$46,221.11	
Excess of redemption value of United States Savings Bonds over issue price		920.00	47,141.11
1941 Convention Expense			143.06
Total Assets			$90,620.44

Liabilities and Surplus

Accounts Payable	$2,871.64
Membership Dues—Advance Payments	13,479.67
Unearned Subscriptions to Journal	1,074.86
Reserve for Award Fund (McCord)	154.56
Reserve for Expenses of Carbon Research Committee	48.46
Surplus, per Exhibit C	72,991.25*
Total Liabilities and Surplus	$90,620.44

* Canadian funds in the Bank of Montreal as at December 31, 1940 amounted to $1,276.12, which, if converted into U. S. currency at that date, would have resulted in a loss of $177.06. Had this loss been recorded, the cash in banks and the surplus would have been decreased correspondingly.

† Back issues of the Journal and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes, inasmuch as the entire costs were charged off during the years of publication.

EXHIBIT A, Schedule 1—Investments, December 31, 1940

Security	Principal Amount	Date of Maturity	Purchase Price
Alabama Power Co. 4½s	$2,000.00	1967	$1,932.50
City of Los Angeles, Water Works Bonds 3½s	2,000.00	1960	2,241.11
International Tel. & Tel. 5s	3,000.00	1955	2,895.00
Province of Ontario 4½s	2,000.00	1946	1,690.00
Province of Ontario 4s	1,000.00	1964	732.50
Province of Ontario 5s	3,000.00	1942	3,105.00
Province of British Columbia 4½s	1,000.00	1951	1,000.00
Southern Pacific 4½s	5,000.00	1977	4,875.00
United States Savings Bonds (issue price)	5,250.00*	1947	5,250.00
United States Savings Bonds (issue price)	7,500.00†	1948	7,500.00
United States Savings Bonds (issue price)	7,500.00‡	1949	7,500.00
United States Savings Bonds (issue price)	7,500.00§	1950	7,500.00
Total Securities	$46,750.00		$46,221.11
Excess of redemption value of United States Savings Bonds over issue price to December 31, 1940			920.00
Total Investments			$47,141.11

* Maturity value at May 1, 1947—$7,000.00.
† Maturity value at December 1, 1948—$10,000.00.
‡ Maturity value at March 1, 1949—$10,000.00.
§ Maturity value at January 1, 1950—$10,000.00.

EXHIBIT B—Statement of Income and Expenses for the Year Ended December 31, 1940

Operating Income:		
Annual dues	$40,598.39	
Advertising	26,626.00	
Subscriptions to Journal	2,910.76	
Convention registration fees	6,156.00	
Convention extra tickets	1,518.75	
Water Works Manufacturers Association	7,500.00	
Interest on investments	1,400.00	
John M. Goodell prize	75.00	
Miscellaneous interest income	4.33	
Total Operating Income		$86,789.23
Publication Income:		
Sales of Manual of Water Quality and Treatment	$1,949.31	
Sales of Manual of Water Works Practice	135.00	
Royalties on Manual of Water Works Practice	30.00	
Sales of Manual of Water Works Accounting	171.73	
Sales of Reprints	2,563.77	
Sales of Census	3.50	
Sales of Cumulative Index	634.81	
Sales of membership certificates	38.80	
Sales of Proceedings and Journals	537.20	
One-half of profits from sales of 8th edition of Standard Methods of Water Analysis	1,187.22	
Sales of specifications—miscellaneous	152.97	
Sales of specifications—steel pipe	1,579.64	
Sales of specifications—cast-iron pipe	3,699.30	
Sales of specifications—fire hydrants	197.96	
Sales of specifications—elevated tanks	317.94	
Total Publication Income		13,199.15
Total Income		$99,988.38

Balance Forward			$99,988.38
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expenses—annual meeting	$2,313.39		
Stenographic expense	158.54		
Executive Committee expense	64.05	$2,535.98	
Administrative Expenses:			
Rent	$3,000.00		
Office supplies and services	4,062.67		
Membership promotion	193.22		
General travel expense	138.18		
Auditing expense	500.00	7,894.07	
Administrative Salaries		26,877.66	
Committee Expense		534.90	
Division and Section Expense:			
Division expense	$40.17		
Section—membership allotment	4,932.59		
Section—official travel	2,564.83		
Section—general expense	89.35	7,626.94	
Biennial Membership List		1,505.92	
Journal:			
Printing	$23,117.17		
Abstractors	585.61		
Storage—Journal paper stock	90.19	23,792.97	
Convention:			
General	$1,596.46		
Entertainment	5,962.58		
Management committee	30.26		
Publicity and attendance committee	268.88	7,858.18	
Membership Dues in Other Associations		575.00	
John M. Goodell Prize		75.00	
Fuller Memorial Award		6.90	
Depreciation of Office Equipment		476.19	
Miscellaneous Expense		67.76	
Total Operating Expenses		$79,827.47	
Cost of Publications Sold:			
Manual of Water Quality and Treatment	$1,689.67		
Manual of Water Works Practice	106.94		
Manual of Water Works Accounting	103.24		
Reprints	2,297.75		
Census	1.50		
Cumulative Index	476.21		
Membership certificates, including lettering and mailing	59.44		
Specifications—miscellaneous	172.60		
Specifications—steel pipe	1,454.85		
Specifications—cast-iron pipe	2,204.17		
Specifications—fire hydrants	128.94		
Specifications—elevated tanks	263.14		
Total Cost of Publications Sold		8,958.45	
Development Expenses:			
Committee Expenses—Methods of determining fluorides		60.00	
Total Expenses			88,845.92
Net Income for the Year (Transferred to Exhibit C)			$11,142.46

EXHIBIT C—SURPLUS ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1940

Balance, January 1, 1940	$61,848.79
Add: Net Income for the Year, per Exhibit B	11,142.46
Balance, December 31, 1940, per Exhibit A	$72,991.25

Membership Statement for the Year 1940

	ACTIVE	CORPORATE	ASSOCIATE	HONORARY	AFFILIATE	JUNIOR	TOTAL
January 1, 1940	3,119	294	200	24	59	14	3,710
Transfers in membership grades	4	—	—	—	—	−4	—
Transfers in membership grades	−4	—	—	4	—	—	—
	3,119	294	200	28	59	10	3,710
Gains:							
New Members	421	32	16	—	30	15	514
Reinstatements	51	5	2	—	—	—	58
	3,591	331	218	28	89	25	4,282
Losses:							
Resignations and Deaths	97	4	8	3	1	—	113
Dropped for non-payment of dues	186	10	6	—	10	—	212
Total December 31, 1940	3,308	317	204	25	78	25	3,957
Total January 1, 1940	3,119	294	200	24	59	14	3,710
Gain in Year 1940	189	23	4	1	19	11	247

Comparative Statement—Gains and Losses—Ten-Year Period

YEAR	NEW	REIN-STATED	RESIGNATIONS AND DEATHS	SUSPENDED FOR NON-PAYMENT OF DUES	GAIN OR LOSS	TOTAL MEMBERS AT END OF YEAR
1931	203	22	123	216	−114	2,717
1932	117	22	169	297	−327	2,390
1933	168	56	159	234	−169	2,221
1934	271	66	86	122	+129	2,350
1935	565	42	85	190	+332	2,682
1936	311	53	104	218	+42	2,724
1937	515	86	122	139	+340	3,064
1938	520	59	144	140	+295	3,359
1939	578	64	112	179	+351	3,710
1940	514	58	113	212	+247	3,957
Totals for Period	3,762	528	1,217	1,947	+1,126	

ABSTRACTS OF WATER WORKS LITERATURE

Key. **31**: 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31**: 3: 481 (Mar. '39) indicates volume 31, number 3, page 481. Material enclosed in starred brackets, ★[ ]★ is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British); C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts; W. P. R. Water Pollution Research (British); I. M.—Institute of Metals (British).*

DEFENSE

A.R.P. [Air Raid Precaution] and Water Undertakings. GRANVILLE BERRY AND ALAN BOOTHMAN. Wtr. & Wtr. Eng. (Br.) **42**: 297 ('40). *Excerpts.* "In recent years there has been a growing tendency toward greater co-operation among water undertakings and a more regional aspect has been given to the whole problem of water supply and distribution; and with the increasing responsibilities to the Civil Defence Services the need for national planning of water resources has become even more apparent.

"Whenever possible the A.R.P. [air raid precaution] scheme of a water undertaking should include an effective system of mutual assistance, not only in respect of alternative supply, where this is practicable, but also of water repair parties, spares, equipment, mobile sterilisation plant, etc., in order to ensure that in the event of the personnel, equipment, and other resources of an undertaking being insufficient to meet the demands placed upon it after a heavy raid, the whole available resources of the unaffected part of the region could be thrown into a combined and immediate effort to meet the particular local needs.

"If an undertaking is to meet the responsibilities it is called upon to bear, then wastage must be eliminated whether that wastage arises from leakage in trunk mains, distribution and service pipes, or domestic fittings. Any engineer, who has carried out systematic waste detection, knows that, speaking generally, wastage from domestic fittings accounts for the bulk of water lost.

"The systematic replacement of old mains by new, which has been proceeding in some areas as a long-term policy, has become increasingly difficult because supplies of iron and steel are being diverted to various forms of war effort, but the need for replacement of encrusted mains has become almost equally important, and it is particularly essential for the fire service that mains should develop the maximum pressure and delivery possible for the size of the pipe.

"The main problem must necessarily be to obtain sufficient water for fire fighting purposes in an emergency, particularly where extensive damage has occurred; and the fire service should not rely exclusively upon water from the public mains; it is essential that this service be made as independent as possible by utilising such river and other water as is locally available and by the frequent provision of storage tanks in areas where certain physical or engineering difficulties prevent the satisfactory inter-connection or linking up of mains, or where damage to mains is likely to cause serious dislocation.

"There has been a tendency in recent years for experienced turncocks [servicemen] to be attached to central fire stations to deal with water supply

problems that arise, and their knowledge of the layout and disposition of mains, hydrants, valves, etc., is of invaluable assistance. A similar arrangement may conveniently be provided to deal with auxiliary fire services with turncocks attached to auxiliary fire stations where they are readily accessible to the patrols, and able to effect such diversion as may be necessary to make additional supplies of water available.

"It will generally be found that the main difficulty has been less an engineering one than one of assessing the probable vulnerability of the various parts of the supply and distribution system, and taking adequate safeguards to ensure that, whatever damage may result from aerial attack, it will still be possible to carry out the functions of the undertaking in some form in the affected area or areas until repairs and replacements have been effected.

"The chief problem of the protection of supply is not so much one of the type of protection to be given as the degree of protection economically justifiable, having regard to the position and vulnerability of the supply.

Impounding Reservoirs

"The impounding reservoir cannot be hidden from aircraft and, although it has been stated that such reservoirs would be difficult to locate and still more difficult to hit, this is not the view today of many responsible water engineers. Not all dams are fortunate in having very high ground at their extremities, and aircraft flying at 1,000 ft. above the crest of a dam would in most cases clear such obstructions. If their flight is along the line of a dam, the chances of direct hits may be considerable and steps should be taken to provide reasonable protection.

"If it is considered that a stone or concrete dam could not be effectively destroyed by a direct hit, an earthen dam presents a more vulnerable object, and the penetrative effect of a delayed action bomb might reasonably cause the destruction of the upper portion and seriously jeopardise its stability if the released water appreciably eroded the supporting earth. No one can forecast the effect of shock on the water-retaining core wall of a bomb exploding on the downstream bank, and even if total destruction were prevented, serious leakage might be caused which, as experience has shown, would be extremely difficult to seal.

"Steps to reduce scouring through a breached earthen embankment are difficult to suggest, and to reduce water depths even by 5 ft. in reservoirs would cause a constant strain on every undertaking in its attempt to meet even normal demands.

"It has been suggested that filled sandbags or barges should be available for use to stop scouring, but it would be very difficult to convey barges to most impounding reservoirs and it is preferable to build up rafts on the site which could be floated to the breach and supported by filled sandbags.

"*Valve Towers* are generally small and unlikely to receive a direct hit by bombs, but the contingency must be guarded against by duplicating the controls where possible—say, at the foot of the embankment.

"*Service Reservoirs* are either open or covered, but, though relatively small, they form an important part of any water works system. Whilst the covered reservoirs will be invisible from the air and still able to function if only one compartment is damaged, the visible open reservoir, which is rarely divided, might be destroyed by a breach in the enclosing embankment, but the sudden release of stored water, though serious, would not be a catastrophe. Valve houses should be protected against splinters and, wherever possible, by-pass pipes should be provided round a reservoir and at a distance from it; reducing pressure valves might be utilised to prevent undue pressure rises in the distribution system and, what is more important, some measure of continuity of supply would be assured.

Stations

"The machinery installed in pumping stations can generally only be protected against splinters and incendiary bombs.

Adjacent stations however should have their delivery mains inter-connected, and in every case by-passes should be constructed to avoid failure by damage to any concentration of pipes close to a pumping station. The erection of a temporary stand-by pumping set in its own temporary building should be arranged at isolated stations and mobile units certainly provide the best solution where there are many pumping stations within the area. The necessary connections would be arranged before the need arose from the emergency unit to be used.

"*Filter Beds* are easily seen and difficult to protect, but here again by-passing appears to be the solution so long as the unfiltered water can be sterilised, even if this be performed by temporary apparatus.

"*Pressure Filter Plants* are equally vulnerable, and similar protection should be afforded as at pumping stations, but by-pass pipes can be provided and emergency treatment applied as with filter beds.

"*Water Towers* can receive little protection, but, fortunately, they are generally small and subject only to accidental damage. Their chief disadvantage is in affording a distinct landmark to enemy aircraft, and they should be effectively camouflaged. Tanks supported on open frames in reinforced concrete might better withstand accidental damage if panels were bricked up, because failure of a single member might conceivably jeopardise the whole structure.

"The trunk main, as such, is not likely to be the object of direct attack, as it is generally hidden by the earth cover except at river, road, or railway crossings and, being relatively small, presents a poor target. There should be adequate control valves, and automatically self-closing valves—a common peace-time practice on many large aqueducts—have been usefully employed to prevent unnecessary waste of water. Where a large flow is required for fire-fighting purposes, self-closing valves would require special supervision for they would operate to curtail the abnormal flow as if it were caused by a fractured main.

Emergency Repairs

"The success of any A.R.P. scheme of an undertaking will largely be expressed in the rapid and effective repair and replacement of damaged mains where supply has been interrupted and the by-passing and ready provision of alternative supplies.

"The maintenance of supplies will depend on the rapidity with which burst mains can be isolated and by-passes put into operation. To effect repairs on 15 in. or 18 in. mains under ordinary circumstances will occupy the larger part of a working day and, in cases where damage to other public services has been caused, and considerable piles of debris, heavy masonry, etc., are strewn over the site, it must be expected to be a matter of days and not minutes before the repairs are carried out.

"In carrying out emergency repairs, it is not likely that the well-used and tested run lead joint will be of much assistance. Flexible, screwed, Victaulic and detachable joints will generally be required in repairing fractured pipes, and a large number of proprietary fittings have been made available by well-known and reputable manufacturers. These include gland connectors for use where debris is encountered, and telescopic pipe sections for bridging craters of a type likely to be caused in areas free from buildings, as well as flanged gland connectors for use with flanged pipes. A further precaution to be taken is to fit fire hydrants or hose units on the connector. Other systems adopt the method of swivelling the steel tubes used, whilst taper castings may also be used on fractured mains with self-adjusting and bolt-type gland joints. The advantages and disadvantages of each type for the particular undertaking must be carefully considered, and in this respect the responsible engineer is alone best fitted to judge the potentialities of a particular fitting.

"There should be available in every undertaking of moderate size at least one portable chlorination apparatus which can be moved easily to any open body of water, such as clean water basins, open service reservoirs, etc.,

where treatment might be required. Even though the water after treatment at filter stations be sterile and all pathogenic germs and bacteria rendered harmless by chlorination or ozonisation, pollution might enter the water works network through acts of sabotage, or through the access of filth into the distributing pipes via ball hydrants on damaged lengths of pipes. Many mobile sterilising units are on the market that are composite in every sense; these units generally merely require at the most two tappings from the nearest suitable water pipe, in order to inject chlorine gas direct or in solution into a pipe under pressure.

"If attempts are made to land parachute troops in this country, the dosage of chlorine considered adequate for peacetime use should be increased considerably, for one of the objects of the enemy troops might be the pollution of water supplies. They would know the uselessness of applying pollution in impounding reservoirs, since most waters are treated after storage; they would, therefore, direct their efforts to such parts of our works as service reservoirs as are located near centres of population.

"As a measure of guarantee of domestic supplies, tank wagons would be especially appreciated by the public, and such a unit could be arranged on very simple lines.

"Power valve-closing units would be particularly useful on large-size sluice valves, and power picks, supplied with compressed air from a portable air compressor or with self-contained power unit, should have their place in the A.R.P. equipment.

"Mobile booster pumping outfits are also available with armoured suction and delivery hose up to 8 in. diameter, and capable of pumping over 1 mil.gal. a day against about 350 ft.

"A composite unit which incorporates a rotating fine strainer and pump, possibly with chlorinating gear, is a useful item of plant in emergency, for it makes possible the use of a polluted and otherwise dangerous source of supply up to some 30,000 gal. per hour.

"Whatever the form of organisation adopted for the water service, it must not only ensure the efficiency of its own service; at the same time it must also maintain the closest co-operation with the fire-fiighting, decontamination and other local services, as well as work in a mutually beneficial manner with adjoining water undertakers.

"The method by which control could be effected would largely depend on the size and extent of the undertaking, but for larger undertakings a main operational depot and sub-depots should be arranged, preferably with the engineer and such technical members of the staff as are available at hand to deal with serious engineering problems that may arise, and to co-ordinate the work in several areas. To the main and sub-depots, as also at the auxiliary fire stations, turncocks should be attached to proceed to the sites of damage and to be available for advice as to the size, capacity and disposition of mains and valves in the area served by the depot.

Repair Crews

"Water repair parties, stationed at depots ready with tools, plant and equipment, should be available. Whether or not it is necessary to have these parties continuously on stand-by duty by day and night at main and sub-depots is a matter to be decided by individual undertakings in relation to the vulnerability of the supply area and the ease or mobility with which an emergency can be met. Generally, the most satisfactory arrangement appears to be to have one party continuously available at the main depot, and a well-designed rota of duty on call that will ensure the rapid mobilisation of repair parties on receipt of warning.

"At each depot there should be continuously available complete sets of equipment and tackle ready for loading into wagons by day or night, additional pipes, mechanical joints, etc., being available at certain clearly defined points in the district, as well as at the sub-depots. This decentralisation will make for efficiency and rapid action in any part of the district under the worst conditions and also ensure the continuance of the service in the remote event of serious damage to the main depot.

"In certain areas it may be possible to obtain the part-time services of operative plumbers, who have served an apprenticeship and have had subsequent experience on water supplies. When given the additional A.R.P. training these men should be admirably fitted to assist when the normal personnel are hard-pressed with innumerable fractured mains.

"In dealing with repair work, it should be realised that conditions may be such as to make it impossible to deal with all repairs to fractured mains at the same time or as soon as they occur, and it is essential that the largest, or those most likely to dislocate the functions of other Civil Defence Services, be tackled first; and where considerable delay is bound to occur in the repair of mains largely for domestic use, some form of temporary domestic supply will have to be arranged until repairs can be effected.

"It is obviously essential that each member of the party should have a clear idea of his part of the job, and a regular inspection of valves should be instituted to ensure ease of operation and effectiveness in cutting off flow. All valve boxes should be "ringed" in white or yellow paint, and lids kept in such a condition that they can be readily found and easily removed when required, and not left in poor condition, as frequently happens, until an emergency arises."

Discussion

Discussion: Ibid. **43:** 32 (Feb. '41). D. H. B. Reynolds:

"Periods of 'alert' sometimes cover most of the hours of daylight, and bombing and gunfire often occur spasmodically throughout the day, retarding outdoor work. It recently took a week to relay 72 ft. of 18 in. main owing to difficulties from water, debris, and incessant air raids whilst repairs were in progress. The last named difficulty may well prove to be a serious one where important mains cross a 'target area.' In this case the actual relaying took only a few hours and could not have been materially accelerated by the use of mechanical joints or other special appliances.

"A policy of dispersal has also been adopted in the distribution system, which consists of three large and three smaller trunk mains, following four different routes to various parts of the town from reservoirs at three different levels. In recent years a system of intercommunication mains and dividing valves has been completed, making it a fairly simple matter to dispense with any one of the larger trunk mains and almost any one of the three smaller ones at the same time, and to supply the whole district from the four remaining trunk mains, often by bringing water from a high or intermediate level reservoir through the low level district in the middle of the town. This arrangement has been found to be a great asset, and on the two occasions on which the larger trunk mains have been put out of action by bombs, a supply by an alternative route has been provided in two or three hours. The service mains have also been inter-connected wherever practicable, and numerous valves have been installed.

"Turncocks, watermen and repair parties should stand by continuously and others should report for duty when a warning is sounded. In this area only eight turncocks are employed, including the foreman and assistants. Two of them reside at the office, and one or other of these two is always on call except during office hours, when both are out in the district. The turncocks are divided into two watches of four, each watch being on call for a week at a time, during which they remain in the town. When a warning is sounded they carry on with their ordinary work unless it is necessary to take cover. If bombs fall in the district, and only then, do they have to report or telephone to the office. This arrangement has been found to work well in practice, and it has the great advantage that the turncocks do not become tired or stale from endless periods of 'standing to.'

"A regional scheme of mutual assistance could do much to expedite the repair of damage, and the authors do well to draw attention to the advantages which could be obtained from regional control.

"The suggested 'Hints and Advice to Consumers' hardly seem appropriate to the conditions now prevailing here and it is doubtful whether the public would

pay much attention to them without some evidence of real urgency. In the event of the suspected pollution of a reservoir it should usually be possible to shut off the supply from it and to substitute another. Similarly if insufficient water were available for fire fighting, hospitals or decontamination, it would be necessary to restrict the supply to the areas urgently in need of it."

W. C. Knill: "The organisation of an A.R.P. scheme for a water undertaking depends on a number of factors, one of the most important being the density of the population over the area supplied. The methods found suitable in one case, where a population of about a quarter of a million people are supplied within 17 sq.mi., would be different from those required with a more scattered population. The chief advantage of an urban area of supply of this type is that, although the percentage of the total number of bombs dropped which damage water mains is greater, the provision of alternative supplies is easier and the 'incidents' can be quickly controlled by the turncocks. For example, although a considerable number of mains, varying in diameter from 21 in. to 3 in., have been damaged, it has, in every case, been possible to provide immediate emergency supplies from adjoining mains to all consumers affected. This would obviously not be possible in the event of damage to a trunk main supplying an outlying town or village and in such a case a temporary repair, involving the use of rapidly made joints, would be necessary. Although a supply of this type of pipework and joints has been provided, I have not, up to date, found it necessary to use them. Experience has shown clearly that the type of temporary pipework with flexible joints which could be laid round a crater would be the most useful and in many cases the only practicable solution, owing to debris in the crater and the necessity for repairs to sewers or other services below the water main.

"It has been found necessary to have repair parties standing by continuously. In many cases considerable work is necessary on the part of the highway authority in clearing the crater of debris and the majority of the damage occurs during the black-out period when the commencement of repair work would be extremely difficult, if not impossible.

"The provision of small cars for the turncocks has been found invaluable, particularly during 'barrage' and black-out conditions. It is obvious that the isolation of any damaged main is of the greatest urgency and even a small main, although not distributing sufficient water to endanger the supply, may reduce the fire fighting supplies or may cause flooding of underground shelters.

"Tank wagons for emergency supplies have not been considered necessary. Hydrant standpipes fitted with bib taps are fixed on the nearest undamaged main and consumers are, without undue inconvenience, able to draw their supplies at these points until their supplies are again available. Every consumer in an affected area is notified immediately, regarding the point from which he can obtain a supply.

"The decentralisation of central stocks of pipes and other stores is a troublesome yet necessary precaution.

"The pernicious habit of relying on the 'grand old man of the department' to remember the position of mains and valves and the lack of complete records cannot be too vigorously condemned. When existing records are considerably out of date or inaccurate the preparation of new records is a laborious task, particularly if the 'grand old man' does not part too easily with his secrets or is deaf! The lack of accurate records will ultimately lead to chaos. All valuable records should be duplicated and copies stored elsewhere, if necessary in a 'safer' district."

J. Noel Wood: "Water engineers in areas badly hit cannot be expected to have time to broadcast their experience for the benefit of their colleagues.

"No two undertakings are alike, but there are certain fundamentals common to all. As far as the distribution system in the town areas is concerned, the essential duties in order of importance would appear to be:

"(1) The immediate closing of valves on both sides of, and as close as possible to, the damaged portion of the main.

"(2) The by-passing and other arrangements for maintaining the supply.

"(3) The repair of damaged mains.

"(4) The provision of alternative supplies from adjoining authorities and/or private sources.

"(5) The steps necessary to deal with contamination.

"In the area with which I am concerned, the above duties are being dealt with as follows: (1) and (2) Eleven 'Patrol Stations' distributed throughout the town area near to the most important points in the system are manned by 35 regular employees and 13 auxiliaries recruited from the local Master Plumbers' Association. These stations are nearly all established at air raid wardens' posts and are in direct telephone communication with the water works liaison officer at the central A.R.P. control. The men go to their stations whenever (by day or night) the 'alert' warning is received or it is evident that an attack has been made on the town. They are provided with full equipment, including protective clothing, diagrammatic plans of the mains and valves in their district, electric torch, first-aid outfit, message forms and envelopes, valve keys, lifting keys and hammer.

"As the quick closing of the valves is the first and most important operation to be done, it has become a regular routine for the patrol men themselves to go over all their valves, see that they are properly greased, and partially work them. This ensures that the men become thoroughly familiar with their district and, what is of great benefit, materially improves the easy working of the valves which normally are very infrequently operated and difficult to move.

"To speed up the rate of closing large sluice valves, some undertakings are using portable petrol engine-driven gearing. These machines should be of great value in shutting off a main quickly and, in areas where the unbalanced pressures are not very high, they would appear to have a claim for inclusion in the Department's A.R.P. equipment.

"In many cases by-passes can be used so that comparatively little property will be without water direct from the mains. Where this cannot be done, hydrant standpipes and hoses linking round the damaged portion of the main offer a quick method of keeping a partial supply going. Water tanks mounted on lorries are also available for distribution throughout an affected area, and special hydrant standpipes with bib taps are ready for the public to use should the supply be off for a lengthy period.

"(3) In my area it has not been considered necessary to have the repair gangs turn out until the 'raiders passed' signal is received. By the time they have assembled at their depots, the extent of the damage will have been assessed and work can be directed on to the most important of several damaged mains. Duplicate sets of tools and equipment have been provided in alternative stores and depots, and transport is always ready for immediate use. While every effort should be made to get the repairs done quickly, they necessarily are major operations taking many hours and must take second place to the initial work of shutting off the water. Furthermore, it may be that, owing to the proximity of an unexploded bomb, the military police authorities may prohibit repairs being carried out until the area is safe.

"(4) In addition to providing connections into the trunk mains of adjoining authorities and the provision of diesel engine-driven pumps for linking up different sections of the system, a survey of private local sources of water supply in the district has shown that over 2 mil. gal. per day can be made available should the normal supply be completely dislocated for any length of time. Portable sterilisation plant has been provided which will permit even the most inferior of these private supplies to be safely used in dire necessity.

"(5) No matter how efficient and complete the plant and organisation may be to deal with pollution, it is fairly certain that immediate and complete protection against all forms of contamination cannot be guaranteed. The requirement of the Ministry of Health that there should always be a residual chlorine content in the water cannot be completely followed in a large undertaking with mains cover-

ing a very wide area, and if relied upon may give a false sense of security. It therefore seems wise to follow the general instructions, which some authorities have given to their consumers, to boil all drinking water for 15 min. whenever there has been an interruption in the supply because of air-raid damage.

"Although all appropriate steps should be taken to protect the major works such as impounding reservoirs, service reservoirs, filter stations, pumping stations, and aqueducts, the distribution system will bear the brunt of extensive damage."

Authors' Closure: "It is good to know in the light of recent experience that with the possible exception of the complete 'Blitz,' the preparations made by water engineers generally are more than adequate to meet the needs placed upon them.

"Before the war the length of time that would in some cases elapse before mains could be made good where a deep crater occurred and where damage had been caused to trunk sewers and other services was probably not sufficiently realised. It cannot be stressed too much that water men cannot be spared for clearing away debris or excavating down the damaged mains, which is work that should clearly be undertaken by the highways authority.

"The 'Blitz' has shown the almost absolute dependence on the water undertaking of the fire fighting services, but a great and perhaps a most unexpected difficulty has arisen through the collapse of buildings over hydrants, valves, etc., and however well designed the system of valves and by-passes may be, it is of no use at the critical period if those valves and hydrants are covered by masses of masonry, roof trusses, etc., that make it impossible to use the additional fittings provided.

"The work of turncocks has become more hazardous than was at first anticipated by the extensive use of delayed action bombs and, where such are found that are likely to damage water mains in the event of their exploding before the Bomb Disposal Squad of the Royal Engineers can deal with them, the wisest policy is to isolate and by-pass that part of the undertaking that may be affected just as if the bomb had actually exploded and damaged the mains in that area.

"Insufficient consideration was given before the war to the provision of emergency supplies which may have to be carried for some miles over piles of debris and around buildings.

"The formation of mutual assistance pools throughout the country has been amply justified in recent months, for many instances are known of authorities providing, almost immediately, every available assistance in personnel, fittings and equipment to other authorities where the effects of bombing have been considerable and water supplies dislocated.

"It was explained that by co-operation the necessity was obviated for any one water undertaking having to lay in stocks of pipes, valves, plant, etc., sufficient to deal with any emergency, and it was eventually agreed that materials and special plant should be pooled and deposited at convenient depots. In this way a very considerable saving to the pockets of the ratepayers was made. At the same time, alternative means of supply were investigated and many adjoining undertakings, by means of cross-connections, obtained an alternative supply in the event of interruption to their own.

"Squads of men were furnished with equipment and tools for emergency repairs, and it was agreed that in the event of any particular district sustaining damage beyond the ability of the local squad to tackle, those of adjoining authorities would be dispatched to render assistance."

Should War Come! *Lessons Learned in England in Coping With Damage to Water Systems, and How to Meet Emergencies.* Victor J. Wilmoth. W. W. Eng. **93:** 1570 (Dec. 18, '40). Authority on air raid protection from London, Eng., gives suggestions on meeting war dangers. Water supply not only necessary for drinking and washing but even more important for putting out fires following dropping of incendiary and high explosive bombs. Main forms of possible attack on water system are: sabotage, parachutists, high explosive

bombs, incendiary bombs, gas bombs, bacterial infection. Camouflage, a great help in protecting bldgs., should, however, be left to experts. Open bodies of water cannot be disguised. Sabotage possibly more to be feared before war declared than after, best defense is a trustworthy staff of permanent employees and engagement of as little casual labor as possible. All employees should have passes and plant closed to all others; passes should contain photo of holder. Vital bldgs. should be fenced and under war conditions guarded with a sufficient number of men to hold off force of parachutists until military aid arrives. High explosive bombs may range from 100 to 1,000 lb. in size, protection of bldg. against direct hit by these not impossible but extremely costly. English standards of protection based on a 500-lb. bomb falling 50′ away; wall thicknesses to resist splinters and blast on this basis are: mild steel, 1½″; bricks in cement, 13½″ solid; reinforced concrete, 12″; sand or earth revetments, 2½′. All windows and door openings should be provided with screen walls to these thicknesses for a min. height of 6′. Gravity masonry dams unlikely to seriously affected; earthern embankments may suffer damage. Mass-concrete sunken reservoirs present little risk; elevated storage of any type difficult to protect. Complete system of isolating valves at frequent intervals recommended, as well as tie-ins to other systems. During peace time, as large a stock of all essential spare parts as possible should be laid in with ample reserves of every type of fitting which may need replenishment. Stock should be spread over several depots; and should be built up early, as all metal supplies become scarce during war. Accurate system maps are essential. Emergency supplies should be located and prepared for use. Poison gas not likely to prove very effective against water systems. Mustard gas and lewisite two most persistent war gases likely to be used; both hydrolize slowly in water and to contaminate entire reservoir large quantities would have to be used; any attack of this size would be known and supply could be taken out of service. Boiling will destroy effectiveness of mustard gas but not of lewisite which, on decomposition, still yields arsenical poison. Bacterial infection can be circumvented by adequate disinfection. Author advises early preparedness; states "to be prepared is to meet troubles more than halfway."—*Martin E. Flentje.*

Measures for Air Raid Protection for Gas and Water Distribution Systems of Cities. Eugene Landel. Gas-u. Wasser. (Ger.) **81**: 566 (July 30, '38). *Excerpts.*

"The problems of distribution system service in war time consist principally of maintaining service in the most far-reaching manner possible for both water and gas in order to (1) provide the population with the vital necessities of gas and water; (2) maintain the production of industrial plants using gas and water; and (3) maintain the fire extinguishing power of fire departments to the utmost by providing the vital fire water supplies.

"To carry out these objectives, the problem of air raid protection for the distribution system has been placed in the hands of the operating crews and the reconstruction crews of the gas works' air raid protection troop. The safety and protective service has the general problem of relieving all damage which occurs on and adjacent to the street during an air attack and which may affect the public safety and order. Primarily, the gas works' air raid protection troop is only responsible for the protection and maintenance of the operations inside of the franchise territory. The gas and water operating crews assigned to the safety and assistance services have the special problem of undertaking the correction of difficulties resulting from damage to the distribution system. This includes the extinguishing of fires in mains in the gas distribution system as well as shutting off such mains. Similar work may have to be undertaken in the water distribution systems, such as the closing of gate valves, in order to take damaged transmission sections out of service for repair.

"In the case of larger works, these services are insufficient, and there must be further squads in the picture of the

air raid protection system which are employed for more than the vital reconstruction work. In any case, there must be the closest co-operation between the operating crews and the reconstruction crews at all times.

"In the water supply system, we generally have a large number of valves so that it will be possible to close off stretches of individual piping with relative ease, in case of damage. Difficulties in the operation of the water distribution system result from cases where there are several zones serving different levels. These zones are tied together by interconnections and zone-valving arrangements so that, in case of need, water may be distributed from a higher elevation zone to a lower one. For patrolling the distribution system of gas and water supplies in event of war, it is desirable to assign the operating squad of the safety and protective services and the reconstruction squads of the works' air raid protection troop to this work. Appropriate men should be selected and trained for the reconstruction squads and as squad leaders of the various squads and crews. These should be men who are normally entrusted with such work in their regular peaceful occupations.

"For the personnel of the safety and assistance services, men should be selected who possess the technical qualifications but who, in general, have nothing directly to do with the construction and operation of the public distribution system. These would be men like meter readers, shop workers, fitters, etc. The sub-division of air raid protection into specific air raid duties is well known. For every specific sub-division, it is necessary to have an industrial counsellor as well as the appropriate industry squads with their industry squad leaders. These industry squads are, to a certain degree, to be trained and designed in line with the subsequent work which must be done by the reconstruction squads. The industry squads have the duty to carry out the following *immediate measures* when damage occurs to gas or water distribution systems.

"1. Recognition of the nature and location of the damage and detailed inspection of it.

"2. Removal of water mains from service as far as this is necessary and as far as it is possible by the industry squad; extinguishing of gas fires wherever gas mains have been destroyed as well as temporary restoration of service in the damaged areas in gas and water mains as far as can be carried out within the means of the industry squad.

"3. Immediate notification to the industry counsellor located at the air raid protection division of the works' air raid protection, with a view to permanent preparation of the damaged areas, that is to say, actual further repairs or redispatching through the distribution system—a problem, the solution to which can only be properly supervised by the works' air raid management.

"Closest intimate co-operation of the responsible management of the works' air raid protection with the local air raid protection leader is absolutely necessary. For example, the detailed measures required under measure (2) may be explained as follows:

"In case of a major fire, the valves of the water service connection in each house in the damaged area must be closed and also the main gas and water lines that penetrate or lay through the burning area must be removed from service. (It is a foregone conclusion that these acts would automatically stop the effectiveness of individual house fire companies in the case of major fires. Judgment is necessary in the event that local fire company is still using a given house connection.) Closing of the individual house section will probably always be necessary in the burning area to minimize water losses in the bombed section. If dynamite is to be used for the extinguishing of the fire, then the emergency fire cocks of the gas connections will have to be closed and the risers behind the fire cocks separated so that additional fire hazard and danger will not occur. It is most important to supervise the use of hydrants. No case may be allowed to occur in which unauthorized use of hydrants will result

in taking water for fighting smaller fires and thereby removing available water supplies for fighting a major fire which would be needed to protect a war industry or an industry important to life and sustenance. The necessary rules for this supervision will have to be given by the industry leader in connection with the leader of the safety and assistance services.

"Ordinarily, it will not be the duty of the industry squad to take transmission mains out of service or to undertake the rearrangement of zoning and dispatching as may be ordered by the works' air raid protection. The reconstruction squad for the distribution system must take care of the following duties:

"1. Safety of distribution of gas and water in the case of major fires and in the case of main damage, requiring re-zoning, removal from service of major transmission and distribution mains. They also have the duty to carry out all such measures in the distribution system whose results can only be supervised and judged by the works' leader.

"2. In an emergency, the reconstruction squads can ask for the assistance of the industry squads and safety and assistance services with the permission of the local air raid protection leader of the works' air raid protection. This may only be done if the place where they are to be used is so located that the industry squads may, in event of danger, be able to reach their scene of duty readily and quickly.

"The reconstruction squads have the unqualified responsibility of restoring the distribution system following an air raid. Thereby, they will strive to restore service to the customers. These squads are to be provided with service trucks designed for reconstruction service in which all of the necessary appliances for reconstruction can be put. These squads also have the duty, if necessary, during an air attack to assist the industry squads in removing damaged mains from service and undertaking various re-routing arrangements in the water distribution system, if the industry squad cannot alone take care of the damage. For this purpose, special groups of two to four men may be trained and provided with small, mobile private autos designed with the necessary equipment for assisting in these duties. In such cars, only the most essential appliances for re-routing services or discontinuing service will be carried. The establishment of special squads, fire protection, poison gas protection, etc., as have been provided in the works' air raid plan, may be dispensed with as the needs for the distribution system are concerned. Experts in sanitation should be divided among the individual squads of the distribution service. Particular significance is to be placed on the necessity for apprenticeship of the air raid protection personnel for the distribution system with the regular problems of gas and water distribution.

"The leaders and sub-leaders of the industry squad and the reconstruction squad are to be given distribution system general plans in the scale 1 to 5,000. These maps do not have to be kept up to date continually as is done with the works' maps, but may be reprinted from time to time. It is recommended that photographic reduction of the city plants on small size sheets be kept in the air raid protection headquarters and in the trucks."

War Tasks of Water Suppliers. KARL KASPER. Gas-u. Wasser. (Ger.) **83**: 623 (Dec. '40). *Excerpts.*

"A great deal of work on the maintenance of water supply has been accomplished since the war began. It is axiomatic that the most urgent task of the water works is to make available water for drinking, industrial use and for the extinction of fire, and to provide it in quantities which will, even under the most unfavorable conditions, be adequate for these purposes. Further, it must be emphasized that the contingencies of war, which require the transformation of many industries into armament works, make sudden increased demands upon the water supply, demands which must be met at once. The quality of water for these purposes must, of course, be completely unob-

jectionable from the chemical and bacteriological viewpoint. Such requirements have led to the adoption of several protective measures, which for obvious reasons can only be hinted at in this article.

Method of Supply

"The facilities for the supply, treatment and pumping of water should always be subdivided as much as possible when it is necessary to expand the system during wartime. Existing plants and neighboring pipe networks must be inter-connected or provision made for their quick inter-connection, at several points by the simplest devices feasible. Further, consideration must be given to the adoption, though under the most economical use of important building material, of additional protective measures to prevent any considerable or long-lasting interruption of the water supply from occurring even when part of the plants or pipe networks have been disrupted. Because of our thorough preparative work and through our adherence to the principle, always taken into consideration in water supply, that reliability of the operation of the works comes first, it is already evident that the water supply to large cities and important industrial districts had been constructed with foresight. Particularly for armament industries, the demand of water, needed for all purposes, has been met satisfactorily by appropriate measures.

"Decentralized water works plants, mains connected in parallel, vast storage facilities and close inter-connection of pipe networks by the ring system must be considered the most desirable aims of water suppliers. Where, in larger cities, the supply district is divided in zones with different pressure, connections between the several zones of the pipe network have been provided to make possible the supply of water from one zone to another one in case of emergency. If possible, motor driven pumping sets on trucks also are kept ready to maintain a sufficient delivery head for carrying the water into zones of a higher pressure. In some cases, pumping stations, already shut down, or which are only reserve stations, have been successfully overhauled and made fit for the provision of an emergency water supply. Further, it has proved valuable to provide prime movers, driven by oil, which can be switched in if steam or electric power should not be available. The co-operation of neighboring works is strongly recommended so that the managers of the plants may help each other, by advice and, in case of emergency, by practical measures. The pipes and fittings for the pipe network, when they are held in store by the large works, may also be made available to other plants, if necessary. During the last winter, [1939-40] experts from various plants were requested to co-operate with manager of plants where particularly extensive damage was done by frost, so that the quickest repair of such damage could be effected. The use of light pipes with clamp couplings which were connected with the hydrants of undamaged pipe lines was successful in the emergency bridging of destroyed pipes of a small diameter. The hydrants and extensions for the supply of water for fire extinction have been standardized so that water works, fire fighting and rescue organizations are able to co-operate without difficulty. Likewise, the provision of the quantities of water needed for air-raid protection in front of and within particularly important and endangered properties has been taken care of in close co-operation with the large industrial enterprises.

"Some of the water works were required to provide large quantities of water very quickly for construction work which, because of its importance for the conduct of the war, was particularly urgent. Additional supplies were also necessary for rinsing water, cooling water and water for other industrial purposes as well as for the consumption of the added population which was involved when army, labor barracks and other important war plants were erected. Such added demands occurred in many localities and required large increases in supply with no delay. To a considerable extent, domestic building materials and methods, using as little iron as possible, were successfully used in the

construction of new buildings, the foremost principle of such important construction being that the substitution of materials and methods should, in no way, impair the quality of the building. The work formulated in the Four Year Plan and its extension to water works structures as announced just a short time ago were examined in thorough investigations; and the data, so collected, were exploited for war construction. These factors are taken into consideration for all work in the water works plants, in their pipe networks and in the plants to be supplied with water.

"For several years the water works have, as a precautionary measure, done extensive work toward safeguarding the water supply; and this work is helpful now, in the war. It was possible, on the basis of these preparations, to achieve all changes within the shortest possible time. Close co-operation of the "Deutsche Verein von Gas-und Wasserfachmaennern" and of the "Wirtschaftsgruppe Gas-und Wasserversorgung" [industrial organization, supervised by the government] with the chairmen of the district of the first mentioned "Verein" and of the district groups [local sub-divisions of the "Wirtschaftsgruppe"] and with the "Wasserwalter" [obviously party (Nazi) representatives] has made available material for appropriate protective measures which could be used where it was necessary; thus, no great disturbances have occurred to date.

Protection of Supply

"During the war, great and important changes concerning the extremely important subject of the protection of the supply facilities have also been made. These changes submitted the efficiency of the management and of the employees and workers to a severe test. Especially in the districts endangered by air raids, the members of the organization for the protection of the plant against air attacks, as well as the men active in the disturbance and repair service, had to risk their lives in doing their work. The courage and unparalleled self-denial with which these men have executed their tasks were the guarantee that the facilities would not be endangered even in critical hours and that damages which occurred could be repaired very quickly.

"Hitherto, it was a very rare exception that people, not working in the plant, had to be used for the protection of the plant and for the repair service. Apart from the maintenance of the plant operation and additional necessities, the employees and workers, both from the plant and the office, were glad to sacrifice part of their spare time for safeguarding the plant against air raids in every respect. Despite the additional tasks, brought about to a considerable extent by the war, it was possible to make numerous men available for service in the army. Suitable craftsmen, draftsmen and designers, who possibly were dispensable, were transferred by the "Arbeitsaemter" [governmental offices for placement of workers] to other factories, important in the conduct of war. Only expert workers who were really needed for the maintenance of the operation of the plant were left at the disposal of their management on its application, but, wherever possible, this was done with men advanced in years.

Increase of Efficiency

"Of course, this considerable additional capacity could be achieved only through the fact that an increased working efficiency was demanded of every man and woman. All activities which were not absolutely necessary were postponed unless the reliability of the operation was reduced. Some persons also could be spared within the administration in consequence of a thoroughly streamlined organization. Just by prolongation of the period between meter readings, in some cases to twice as long, it was possible to avoid much administrative work. Likewise, the period between exchanges of meters could be prolonged in many places with no considerable deterioration of the reliability of measurement. Further, family members of the employees and workers, and women with no previous work connections, were quite successfully used for the simpler operations in running the plant and as office workers in the administrative departments.

"It should not be forgotten that, apart

from all the present contingencies, additional engineers, foremen and craftsmen must be educated in time so that the tremendous work, awaiting the water plants after the war, can be accomplished then. Water consumption will increase considerably through the development of the large cities, the extension of the "Lebensraum" [living space] and the building of new apartments, equipped with an unprecedented amount of modern hygienic installations. Additional works and pipe networks will have to be built. In the course of events the individual water works would attempt at an early date to educate suitable experts, and even now, during the war, the solution of the post-war tasks must be prepared by training employees and workers, by promotion of able and reliable men and by education of apprentices. The "D.V.G.W." already has dealt thoroughly with these questions and is now at work, in co-operation with the "Deutsche Arbeitsfront" [governmental organization which has replaced trade-unions], on a plan for the professional education of a new type specialist i.e. the pipe network engineer. The question of the education of future skilled labor is also an important consideration for public utilities. According to the national socialistic principle of efficiency, a far reaching possibility of promotion must be offered to the skilled worker. At the same time, this will create the basis of a more adequate reward than is possible under existing regulations. He who has successfully completed his apprenticeship as plant locksmith, pipe fitter or pipe network builder and has had several years of experience at his work should be promoted to engine foreman or network foreman or even to chief engineer of a smaller plant after having successfully passed his courses in a technical high school. For this purpose, contributions toward the education of such students should sometimes be granted by the plants which employ them. Since smaller plants cannot generally offer the necessary educational facilities, it will be the task of the larger plants to teach the future experts in suitable training workshops for the neighboring plants of their district; thus, the latter plants would be able to assign suitable young workers to the plants which are doing the educational work for the period of the training course. Administrative reluctance should not create any obstacle since water works cannot be "administered" at all but should be developed to efficient model plants serving the community. This, again, however, can be done only if suitable skilled workers will be available in a sufficient number.

"The technical experience, gathered during wartime, is being collected and evaluated by competent committees of the water works industry. The savings of building material and the changes to domestic products have already been specified in many cases by basic recommendations and by standard regulations. Thus, the multitude of devices hitherto in use has been reduced to an absolutely necessary minimum and numerous construction parts have been thoroughly simplified. These and other activities will be continued eagerly despite wartime conditions."

Damage to Water Mains. Precautions Against Pollution During Repairs. *Extracts from a circular distributed by The Ministry of Health.* Wtr. & Wtr. Eng. (Br.) **42:** 381 (Nov. '40). Damage at present being caused to mains emphasizes need for taking all possible precautions against pollution of supply during repairs. Simultaneous occurrence of break in water main and in sewer in close proximity does not in itself constitute immediate and direct danger to water supply. Sewer is usually below level of water main; water in main is under pressure; and when pressure has fallen off, the water has ceased to be delivered to consumers. Definite risk of pollution at later stage when repaired section of main is again brought into use. Of utmost importance that repaired section be thoroughly washed out and sterilized before supply is reconnected. If notwithstanding all precautions there is reason to suppose supply may have become unsafe, or if, owing to enemy action, damage to works or mains is so intensive and interruption of supply so serious that consumers are

likely to resort to casual water from rivers, etc., consumers in particular localities affected should be warned immediately to boil all water for drinking or culinary use until further notice. Where boiling is not possible, e.g., because of interruption of gas supply, consumers are advised to use chlorinated soda solution, adding 10 drops to 1 pint of water, stirring and shaking and allowing to stand 5 min., and then adding crystal of ordinary photographic hypo. —*H. E. Babbitt.*

The Sterilization of Repaired Water Mains. E. F. W. MACKENZIE. Wtr. & Wtr. Eng. (Br.) **42:** 394 (Dec. '40). Fracture of water mains by high explosive bombs constitutes greatest danger from bacterial pollution of water supplies that water works have, as yet, been called upon to face. Importance of sterilization of repaired mains has been greatly enhanced by damage which has resulted to mains from aerial bombardment, but prior to outbreak of war it had been realized that methods advocated in U. S. would seriously delay return to service of repaired mains and would not, therefore, be practicable in circumstances likely to prevail in war time. Considerable experience has now been gained, both with regard to effects of high explosive bombs on mains and possibility of contamination. Example of section of 18″ main shattered by bomb given. Found that piece, weighing over 100 lb. had been blown approx. 100′ up the main. Exam. of 48″ main showed clay and debris lying in invert for distance of 600′, beyond which main could not be examined because of a dip. Craters have been examined in which no visible evidence of sewage pollution could be detected but in which smell of sewage was so strong as to be unmistakable. Not possible to determine by visual exam. whether or not dangerous contamination has taken place, or to what extent it may have been driven along main. For purpose of sterilization, mains were classified as (1) those smaller than, and (2) those larger than, 12″ in diam. This somewhat arbitrary subdivision was felt to be justified because it was held to be undesirable to drill small mains to allow corporation cock to be inserted, and anticipated that no. of small mains fractured might be so large that it would not be feasible to treat them by somewhat more elaborate method proposed for large mains. It was believed also that discharge of water from both ends of small mains would prevent heavy pollution. Quantity of bleach to be inserted was laid down as sufficient to give 1 p.p.m. of available chlorine in estimated capac. of empty section of main, followed by 1 hr. contact. Bact. analyses showed it to be totally inadequate. For large mains, was decided that injection of solution of chlorine derived from cylinders of liquid gas would be only practicable method for applying desired treatment. Mobile chlorinator was designed, holding six chlorine cylinders and pump driven by petrol engine. Towing vehicle always standing by, ready immediately to take its trailer to wherever it may be required. Better than self-propelled vehicle. Unless spare chlorinators and vehicles are held in reserve to provide reliefs for those which have broken down delay in bringing repaired mains back into service will be inevitable. Soon realized that sewage pollution was not easy to detect and was considered advisable to raise chlorine dose to 10 p.p.m. on all occasions. Chlorination of large mains is carried out by [a trained and centrally controlled organization]. Small mains may be sterilized by means of stabilized bleach, introduced through hydrant, to give chlorine concentration of 10 p.p.m. in estimated capac. of main. Every practicable step should be taken to empty every part of isolated section of fractured large main. Chlorine should be introduced at point at which main is to be recharged after repair. When main is being chlorinated, water should be run to waste through air valve, hydrant, or emptying valve at opposite end from that which is being charged, until presence of chlorine can be clearly demonstrated in water discharging. Main should be allowed to stand fully charged for not less than 15 min. Widespread realization that chlorinous tastes spell safety; and complaints have been

few. Of samples drawn from both large and small mains treated, 100% have proved negative to *Esch. coli* in 100 ml. samples. Admittedly extreme case cited in which method has been successful. Bomb fell on crest of a hill and made crater in which were broken ends of 16" water main and sewer. Crater filled with mixture of sewage and water, which poured into both ends of broken main. Sample drawn after main went back into supply gave following result: *Esch. coli* in 100 ml., nil; 24-hr. colony count at 37° C., 2 per ml.—*H. E. Babbitt.*

Chlorination of Water Supplies. David Ronald. Surveyor. (Br.) **98:** 151 (Sept. 27, '40). Risk that water supplies in Britain may be contaminated by enemy action. All supplies serving pop. of 3,000 or more should now be chlorinated continuously. May not be possible to apply chlorine as gas because: (1) demand for plants may exceed supply; (2) may be difficulty in obtaining steel cylinders or drums; or (3) transport of cylinders and drums may be difficult. Chlorine derived from sodium hypochlorite liable to attack metals and is therefore unsuitable. Chlorine derived from chloride of lime can be used. Easily obtainable and can be obtained in dry form in casks. Quality deteriorates. Dry powder is mixed with water, vehicle which carries chlorine into the water to be treated. Assuming 1 m.g.d. (Imp.) to be treated with 1 p.p.m. chlorine, apparatus required includes: 2 200-gal. (Imp.) tanks, ½" rubber hose, 40-gal. (Imp.) cask. One mil.gal. (Imp.) water requires 10 lb. chlorine or 30 lb. chloride of lime. Between 6 and 7 lb. of water should be used per lb. of chloride of lime. Lime should first be mixed with a little water into a slurry or paste. Point at which liquor should be introduced into supply will depend on local conditions. Convenient method of introducing it is through rubber hose. Flow of chlorine into water should be adjusted to ensure that there is never less chlorine being added than what is required to sterilize, and never so much as to make water unpalatable. Method of testing for free chlorine is colorimetric one. If about 0.2 p.p.m. chlorine present 10 min. after addition, good bactericidal purif. will be secured.—*H. E. Babbitt.*

Practical Methods for Sterilization of the Water Consumed by the Evacuated Populations. R. D. De La Rivière. Mouvement Sanit. (Fr.) **16:** 455 ('39). Evacuated populations [of France], communities which shelter them and neighboring troops stand successively in danger of infectious disease and of water-borne disease in particular. Quantity and quality of drinking water in reception areas is to be investigated and may be wise to establish, at different centers, special units, working in touch with existing civil and military authorities, to deal with matter. Where reliable system for distribution of pure water exists (and all *concessionaires* are by law responsible for purity of water they supply) increased vigilance is alone necessary. Where new distributing installations are contemplated it will probably be simplest and cheapest to depend on chlorine rather than ozone as sterilizing agent. Chlorination, used in U. S. A. and Canada and adopted by the American Army in 1917, effective though it is, appears to the author, after personal study, to make too great demands in manipulation and supervision. Two methods are successfully employed in various French towns: Javelization and Verdunization. As regards former a report to the Conseil Supérieur d'Hygiène points out that water to be treated must be limpid and must not contain more than 3 mg. of organic matter per liter, nor appreciable amounts of ammonia, urea, nitrites or salts of iron. In Paris and certain other towns process is adequately controlled and transit of javelized water to the reservoirs is fittingly prolonged. There is in some quarters a dangerous tendency to think that addition of *eau de Javel* to water renders this forthwith safe. It must also be remembered that active chlorine content of *eau de Javel* varies between 50 and 95 grams per liter, that solution must be stored in well-filled bottles shielded from warmth and light, and that dose proper to water under treatment must be accurately deter-

mined. Where community lacks a mains-supply of pure water, 3 means of dealing with the situation are available: (1) Water sterilized elsewhere may be imported by tank-wagon and stored, as in 1914, in reservoirs of reinforced concrete. According to Manceau, water should not be served to public till 2½ hours after addition of the chlorinating solution nor retained in the reservoirs longer than 12 hours. (2) Water available locally may be drawn and treated, for instance by motor pumps, fitted with an automatic Verdunizing system, such as were successfully employed by Bunau-Varilla on the Verdun front in 1915. There are also at present on trial sterilization plants mounted on trailers, each with capacity of 500 liters and possible daily output of 8,000 liters. Here, "carbo-chlore" method of Gambier is adopted in which water is subjected for 10–30 min. to as much as 10 mg. of chlorine per liter, excess of reagent being then removed by filtration through activated charcoal. Provided that they function reliably and prove serviceable in all types of country, these mobile purification plants should supply best solution of problem. In addition pinnaces, adequately equipped, assist in filtration, sterilization and storage of river water. Best models of these different types of apparatus must be determined. (3) Disinfection of drinking water may be carried out by consumers themselves. Boiling is a simple and effective method and, by shaking, the boiled water may be quickly re-aerated. Bottles plugged with cotton wool may serve for storage and use of weak infusions prevents confusion with unboiled water. Another good method of household sterilization is to add one drop of *eau de Javel* per liter of water and, 10 min. later, to mix in 1 tablespoonful of wine or cider to neutralize excess chlorine and mask any taste. Use, by uninstructed, of filters and of most chemical agents offered on market for sterilization of drinking water is to be discouraged. An exception may be made in the case of iodine provided a procedure such as that of Tanon be followed:

Solution A: Iodine, 1 gram; KI, 2 grams; aq. dist. 200 grams

Solution B: Na thiosulfate 10 grams; aq. dist. 50 grams

To a liter of water add Solution A drop by drop till the color is pale rum. Should color fade before 20 min. add 2 drops more. After 20 min. add 1 drop of Solution B and shake.

These measures to ensure a pure water supply must be supplemented by improving sanitary conditions of evacuee, by isolating sick and by scrutiny and control of those foods which are consumed raw. There is a strong case for multiple vaccinations.—*B. H.*

Bacterial Contamination Improbable as an Implement of War. Carlo G. Flebus. Civ. Eng. **11:** 147 (Mar. '41). *Excerpts.*

"The possibility of an enemy deliberately spreading an epidemic by polluting the water supply of a city has often been discussed. But it is improbable that resort will be had to this dreadful method of warfare—not because humanitarian considerations may be expected to sway an enemy who wages total war, but because the desired results would not be assured.

"Repeated experiments made by various European powers on the pollution of reservoirs have given totally negative results. The mere fact that a certain type of pathogenic bacteria is present in a body of water does not necessarily mean that persons who drink the water will immediately contract the disease. Much depends on the quantity of bacteria absorbed at one time and on the ability of the individuals concerned to resist the infection.

"Most pathogenic bacteria and parasitic protozoa are mesophilic (requiring blood temperature), and are very sensitive to changes of media, ambient temperature, hydrogen ion concentration, and negative or positive ionization of the air. Cultivated bacteria very seldom survive in a new environment. The water in a large impounding reservoir therefore can only be contaminated by aboriginal bacterial flora, and then only when local conditions are such as will foster the growth of the organisms.

"Of 42 or more commonly known dis-

eases caused by bacteria, few are caused by spore bearing types. The majority are caused by mesophilic types which will not survive over eight days in a body of fresh water. Present prophylactic measures taken by health authorities are sufficient to impede the development of an artificially provoked epidemic.

"An epidemic in a nation at war is less likely to occur because of enemy action than because war activities may divert the attention of health departments from their routine prophylactic duties.

"Large quantities of infected material are necessary to poison a large reservoir; however, it would be possible for a saboteur to poison filters, small reservoirs, standpipes, and so forth. To provide against this danger and at the same time avoid expensive and delicate analyses, before the water is delivered to consumers a part should be by-passed through an artificial brook where mountain trout are cultivated in a natural environment. These fish are very sensitive to the slightest change in their water supply, and sharply react to poison of any nature, organic or otherwise, by coming to the surface, emerging their heads, and breathing heavily.

"Although the clarification and purification of water is a recognized biological process, at present there is no standard biological examination for some species or groups of species of plankton protozoa which show a clear-cut reaction to the presence of septic matter and serve as indices of pollution. A quantitative determination for such species would give valuable information, and if supplemented by chemical and bacteriological analyses, would present a true picture of phases and stages of contamination. In certain countries of Europe such biological and ecological determinations are made, based upon test data collected throughout that particular country over a ten-year period.

"It is my understanding that this method, which constitutes a simple way to collect valuable data, has been initiated only recently in the United States. Such studies should be developed throughout the country all year round, in various latitudes."

Toxicological Investigations on Water Containing Yperite (Mustard Gas) in Solution. R. ANDREONI. Clin. Vet. (It.) **62:** 421 ('39). Products of hydrolysis of mustard gas are practically innocuous. Water containing mustard gas in solution causes gastro-intestinal inflammation in rabbit if concentration is greater than 400-500 p.p.m. Ingestion of concentration of 650 p.p.m. has caused 33% mortality. Conjunctiva and gastro-intestinal tract of rabbit have about same threshold of sensitivity as skin of man. Skin of rabbit is much less sensitive than skin of man to mustard gas.—*C. A.*

London's Water Supply. *Statement by the Metropolitan Water Board.* Wtr. & Wtr. Eng. (Br.) **43:** 39 (Feb. '41). 12 months ago, Board advised consumers, as one of items of air raid precautions, to conserve water. Official figures seem to suggest that consumers responded to appeal. Consumption for year ending Mar. 31, '38 was 306,264,500 gal. (Imp.); Mar. 31, '39, 310,109,800; Mar. 31, '40, 298,610,000. Board has been able to meet all legitimate needs without restrictions. Very large quantity of water that is required to fight even small fire is little appreciated by majority of people. Gardening enthusiasts have not been so responsive to appeal. Many gardens today have been turned over to food production, fact restraining imposition of restrictions. Plenty of water for all legitimate purposes, but none to waste. —*H. E. Babbitt.*

Portable Steam Turbines for Emergency Service. *Extracts from an article in the Allen Engineering Review.* ANON. Wtr. & Wtr. Eng. (Br.) **42:** 399 (Dec. '40). Each unit designed to produce 350 brake h.p. and accompanied in service by portable steam-producing unit. Each unit could drive either a d.c. generator to give 250 kw. at 220 to 200 volts, or pair of pumps. No. of units could be combined to provide either water under pressure or electrical energy at any desired point. General requirements as regards portability were attained by adoption of very flat surface condenser shell, thus keeping down

height, and making it possible to mount both turbine and gear on condenser shell. Weight of complete unit is 5¼ tons, i.e., 32 lb. per brake h.p. General technical particulars are: rated continuous output, 350 brake h.p.; turbine speed, 8,000 r.p.m.; gear-wheel speed, 1,500 r.p.m.; steam pressure at turbine stop valve, 150 lb. per sq.in.; normal steam, dry saturated; max. design superheat, 200°F.; exhaust, 27 in Hg. vacuum; circulating water 345 g.p.m. (Imp.); condenser cooling surface, 250 sq.ft.—*H. E. Babbitt.*

Blackouts and Street Lighting. WALTER KNAUSS. Gas u. Wasser. (Ger.) **83:** 112, 126 (Mar. 9, 16, '40). Gives legal requirements. No light shall be visible to normal eye from height of 1,700 ft., neither vertical nor oblique. Illumination of street below light shall not be greater than 0.01 lumen. To fulfill conditions, gas street lights had to be rebuilt, partly by putting blinds to avoid lights from going skywards, partly by blackening of glass, leaving only a small space for light to pass. Construction of several types with new burners are given. Newer ruling regulates, officially, reduction of fees from city to utility because of savings through blackouts.—*Max Suter.*

Directional Illumination. MAX KLARE. Gas u. Wasser. (Ger.) **83:** 102 (Mar. 2, '40). Describes construction and optical properties of street lights used on important street intersections during wartime. Two types used; one illuminates small critical space of street, other gives a horizontal directional light for guidance of traffic. In all only few per cent of normal public street lighting used.—*Max Suter.*

Utilities and the War. HERBERT COREY. Pub. Util. Fort. **27:** 4: 195 (Feb. '41). *Excerpts.*

"The absolute necessity of defending power plants is beginning to be appreciated in responsible quarters. Electric power stations are among the principal targets of British bombers. The reason is Germany's complete dependence on electricity for the production of *ersatz* goods. When Hitler became Chancellor in 1933 the annual production of electricity was about 25 million kilowatt hours. By 1943 a consumption of 100,000 million kilowatt hours is expected. The blockade accentuates the problem, because it means that more and more *ersatz* goods must be made, which already require disproportionately large quantities of electricity. A bomb that bursts an electric power plant asunder therefore spells local industrial disaster. American authorities would like to make our utilities safe as churches used to be, but they have not found out how to do it. Progress has been made. It has at least been accepted that no protection—in fortifying or reinforcement or digging underground—can be set up for the utilities. The job would be too big. This country has more lines of telephone and telegraph wires, more miles of conduit and water supply tunnels and sewerage disposals, more miles of power and light cables and soil and gasoline and gas pipe lines, more oil wells, derricks, refineries, tank farms, oil docks, and tank steamers than all the rest of the world put together. A raided city can take it, world without end. London and Barcelona are proofs, not to speak of Coventry and Birmingham. But the more the utilities are hit the harder it is to take. When light fails and the gas mains must be shut off and water does not come through the pipes and the sewers clog and overflow, evacuation is the next order of the day. 'We know', said an officer of rank, 'what we can do today for the protection of utilities. That is nothing. Nothing except hide them as best we can. That is nothing, too. The only thing any nation or city can do in the event of war is to trust to luck. Luck alone has protected London. Not one of her great power plants had been hit at last accounts. Her water supplies have not been greatly interfered with. Not one of her bridges has been hit, so far as we have been informed, although they are the best targets imaginable. The Nazis have been bombing at such targets relentlessly, but ac-

curacy is not yet possible in bombing. The American bomb sight, of which so much has been said, is probably no better than any other bomb sight, for the reason that daytime bombing is not practicable in face of the improved methods of defense, and in night-time bombing, the best sight is no better than any other sight. The bombs are released hit-or-miss, anyhow. If our coastal or near inland cities were to be raided in time of war, we would be in precisely the same fix as the British are, except that the raids would be fewer because of the necessity of sending out the bombers from ships, which would be under the constant danger of attack from our Navy. 'It is humanly impossible,' he said, 'to protect utilities. A powerhouse could be hidden in a shell of concrete, which could be made thick enough to protect it against any possible destructive force. But no privately owned company can afford to spend the money required. Not even a nation could spend that much. It simply would not be practicable to make all the powerhouses impregnable. There is not enough money in the world and, in the event of war, there are other more pressing needs for money. If we are to go at the job of defending our utilities against destruction in the event of war—I am now entering the domain of pure theory—the only thing we can do is to arrange an intricate system of shifts and cutoffs. If the pipes and conduits and cables in one area are blown up, services could be restored by re-routing, plus the possible use of mobile power and pumping plants.' "

"Granted that utilities can neither be hidden nor defended, it is still the case that no matter what might happen—in the extremely improbable event that this country should be attacked—they can continue to function. No better evidence of this fact can be offered, perhaps, than the record of the Bell Telephone Company during and immediately after the New England hurricane of 1938. Eight states were affected. Floods preceded the hurricane, a tidal wave followed it, and fires mopped up after it. Yet it is within common recollection that telephone service was restored in an incredibly brief time. This was primarily due to the fact that the Bell Company was able to call in trained manpower from all over the United States. As men were sent from Ohio, others from farther west and south replaced them, and they all knew their business. Everything was exchangeable, from men to rivets. A Texan landed in Providence would be dealing with a mechanical equipment with which he was perfectly familiar. No war could do one-twentieth of the damage that water and wind and fire did to New England's telephone systems."

"The British government has been rationalizing electricity under the grid system during the past few years. Some minor power stations still survive in the London area. They are uneconomic and destined to disappear in due course, but as it happens they constitute today, under abnormal conditions, a valuable standby should the large modern works be put out of commission. Destruction of utility properties by bombing has been less serious than expected, and this conclusion is based not only on recent European events but on the two and one-half years' civil war in Spain. It can hardly be that this comparative immunity is due alone to luck. It must be that electric installations are by reason of material and construction less damageable than, for example, hotels and warehouses. Bomb damage to solidly constructed, steel frame buildings is apt to be extraordinarily light, although streets are torn up and small houses destroyed by bombs of the same caliber. Most of the communications' centers, for instance, are protected against crackpots who might do as much harm as the foreign criminals who inspire their lunacies. Some utilities are considering strengthening powerhouse roofs with steel columns, in order that—still in the unlikely event of war—a heavy layer of concrete or sandbags can be used for protection. Windows will—if and when—be sandbagged for protection against shell splinters. Not much attention will be paid to camouflage, for any enemy flyer who raided us would

be provided with aerial maps in which locations would be shown with reference to rivers, railroads, and highways. If and when we were to be thrust into war, subterranean refuges for vital operations would be provided, as well as for oil and gasoline storage. On the whole we are constrained to revert to the rather melancholy finding that there is no absolute bombproof, foolproof protection for utility facilities. But the Bell Company showed the way when it standardized its material and trained its men. American speed and discipline would patch the breaks, just as the repair crews in London are tying the ends together while the bomb crater still smokes."

The Water Supply in the Italian Army. V. P. Gesundh. Ing. **63:** 537 (Oct. 12, '40). Bad experiences in World War caused reorganization. Construction, upkeep and repair of wells, dams, pipe lines, pumping and treatment plants is in hands of eng. corps. Each army district prepares maps showing sources of water and facilities for distribution. Daily requirements are ave. of 3 gal. per man and 11 gal. per house. Min. necessity is ½ of ave. Each unit receives central water station, containing source of water, chlorination and filtering facilities and distribution system. In Italy, surface waters and, where possible, springs are used for supply. River water is treated by filtering through 20″ of sand with velocity of 4″ per hr. eventually with pre-treatment with alum. Chlorination is mainly with sodium or calcium hypochlorite; liquid chlorine is considered dangerous in hot climates. Residual chlorine is eliminated by thiosulfate. Sterilization by ozone and Berkefeld filters has not proved practical; use of ultra-violet rays not yet developed enough. Hardness removed through base-exchange filters; salt removed in vacuum evaporators. Removal of poisons depends on kind of poison but carbon or special filters, as well as chlorination and boiling, are used. Great care taken to keep source of water clean; explosions of gas bombs especially feared—*Max Suter.*

Portable Purification Plant. D. W. Gillette. Eng. News-Rec. **125:** 696 (Nov. 21, '40). Mobile unit developed by U. S. Army engrs. to supply clean drinking water regardless of location or condition of raw water supply described. Only prerequisite is stream or reservoir of sufficient volume to supply demand. Unit is divided into 2 sections—one including pump, hypochlorinator, chemical feed pots for 2 chemicals, and hypochlorite solution reservoir, and other the filter, with all necessary accessories for filtering and backwashing. Pumping unit consists of self-priming, open-impeller centrifugal pump, with pump impeller mounted directly on extended engine crankshaft. Power is supplied by air-cooled, 4-cycle, gasoline engine. Hypochlorinator consists of belt-driven gear unit and diaphragm assembly with capacity of up to 50 gal. per day. Diaphragm is of soft reinforced rubber and pumping chamber is of hard rubber. Sufficient hypochlorite is applied to give residual chlorine content of 1 p.p.m. after 10 min. storage in open vessel. Filter consists of 4″ sand and 18″ gravel. Unit carries complement of 3 men and will purify up to 180,000 gal. per day, depending on condition of raw water. When floodwaters of Roanoke R. inundated water plant at Weldon, N. C., (pop., 6,500) one of these units was furnishing 110,000 g.p.d. of pure water within few hr. of emergency being reported to N. C. Army Engineer District. —*R. E. Thompson.*

Water Supply in Time of War. F. F. Longley. J. N. E. W. W. A. **54:** 355 (Dec. '40). Water supply in time of war discussed under 3 headings: (1) in established cities and towns, (2) in camps, hospitals, ports, railroads, supply depots, etc., serving the armies, and (3) in combatant zones. Water supply official of established community in wartime should be alert not only in ordinary duties but also to those duties particularly due to emergency. Latter may include prevention of sabotage and anticipation and provision of supplies

that may be needed for repairs. Water supply for ports, railroads, supply depots, hospitals and camps may use water from existing works; in such cases, supply works must anticipate and have available water for greater than normal peak loads. In U. S. Army, Eng. and Quartermaster Depts. concerned with water supply. Within an established field of military operations, providing wholesale water supply is an Eng. Dept. function; in camps in U. S., water supply function of Quartermaster Dept. In combatant zone, soldier himself attends to "retail supply" from water points or sources as close to lines as practical. Army Medical Dept. has always had highly important responsibilities in insuring troop water is safe. Lyster bag and standard ampoule of hypochlorite features of quality control. In A. E. F. of previous war, water supply organizations (Eng. Dept.) provided water as safe as practically possible; medical corps provided necessary further care. Discussion given of conditions affecting Army water supply work based on A. E. F. experience. Present warfare of rapid movement introduces new problems of supply; in certain conditions lack of existing water supplies may restrict speed of operations. U. S. Army has provided tables for organization of "Engineer Battalion, Water Supply" in case of war; consists of 25 officers and 628 enlisted men. One battalion will serve a field army. Each has following units at its service: 3 installation sections; 9 mobile purification units; 135 500-gal. water tank trucks; 14 ¾-ton, 2-wheel cargo trailers; 15 ½-ton pick-up trucks; 4 5-passenger cars; 1 motorcycle; and 1 field ambulance. Water supply operations in active field arduous and highly responsible; call for loyal service of men who recognize no limits to energy and ingenuity. In discussion of paper, importance of combating sabotage stressed. Engineer Board has recently taken steps to improve treatment facilities for field water supplies. Present U. S. Army mechanized division contains about 12,000 men; may be rather widely scattered. Planned to provide each important element of army with own water supply procurement and purification equipment; will mean about 4 units per triangular division. A promising small 34-lb. pack filter with capac. of about 2 g.p.m. has been developed. Sanitary Corps has been engaged in developing methods for the detection, neutralization and removal of warfare gases from water. Except in unusual cases, gas contamination can be neutralized or removed so as to eliminate any danger from use of water.—*Martin E. Flentje.*

Camp Water Supply and Sewage Disposal. Anon. Eng. News-Rec. **125:** 769 (Dec. 5, '40). Water supply and waste disposal systems at Camp Ord, near Monterey, Calif., described. Small camp originally on site obtained supply from 250′ well, tapping underground storage of Salinas R. Capac. of well was increased and auxiliary well and new pumps provided to supply 1,000 g.p.m. during 70 min. period of max. use, 4.30–5.40 P.M. Max. elev. for storage tank site was on top of hill 2,500′ from camp and 95′ above it. Mains are of Class 150 asbestos-cement pipe. Main distribution system is of loop type and consists of 6,000′ of 6″ pipe. An 8″ main, 2,280′ long, connects system to 200,000-gal. reinforced-concrete storage tank. Sewage treatment plant consists of battery of settling tanks and sand filters. Up to 4,000 troops and 1,600 animals will be stationed at camp.—*R. E. Thompson.*

Prompt Action Saves Serious Water Situation. Anon. Ry. Eng. and Maint. **87:** 10: 641 ('40). Two days previous to moving of National Guard Units to Camp Shelby on Aug. 5, '40, artesian deep well supplying Illinois Central R.R. terminal at Hattiesburg, where troop trains were to be serviced, failed, due to break in casing. Emergency facilities were installed by System water supply force consisting of temporary pump and line to small creek for boiler purposes and a 3,000′ 2½″-and-1½″ connection to city main for servicing cars and supplying drinking water. No delay to troop train movement occurred. Artesian well was repaired and regular supply returned to service on Aug. 27—*R. C. Bardwell.*

ADMINISTRATION, PERSONNEL AND PUBLIC RELATIONS

Problems in the Management of Municipal Waterworks. L. R. Howson. W. W. & Sew. **87:** 563 (Dec. '40). Revenues should pay operatings costs, interest and amortization of debts, and ordinary extensions to water works system. Depreciation charges in addition seem unwarranted. Expansion out of current revenues costs only 60% of bond-financed expansion, and assures construction when needed, flattening of fixed charge peaks, and reduction of political interference. Perpetual construction program planned 20–30 yr. ahead is desirable to enable adequacy of service, smoothed out expenditures, and reduction of obsolescence. Good bookkeeping and adequate comparative operating statements vitally important. Should be frequent and standardized to allow comparison with other cities, so that unit costs and operating procedures may be adequately controlled. Examples cited of economies made through comparisons. Consumer meter ownership most undesirable, since it encourages under-registration and reduces revenue. Increase in meter size should be accompanied by increase in minimum or service charge. Free water should be metered, and, preferably, sold at a reduced rate.—*H. E. Hudson, Jr.*

The New Regulatory Expert. B. Morton Fullerton. Pub. Util. Fort. **27:** 67 (Jan. 16, '41). Day of specialist in utility industry. Managements have employed tax, accounting, public relations, legal, financial and insurance experts; now beginning to employ new type of specialist—regulation specialist. Function is helping utility to be regulated in least burdensome manner. Generally former member of regulatory body. Effort of utility executives to protect themselves in dealing with regulatory bodies by relieving themselves from appearing before commissions and so saving their time to attend to regular managerial functions. Because representatives of regulation demand considerable statistical information and substantial concessions; because of vacillating opinions of S.E.C.; and because regulation is theoretical rather than practical, experts are useful in this way. S.E.C. consumes long time in handing down opinions, especially when plan is similar to previously approved similar plans and is meritorious and beneficial to security holders. Assuming justification for deferring final opinion, still difficult to approve practice of S.E.C. in delaying holding hearing until several months after filing of proposal. Even on apparently routine matters, numerous trips to Washington by utility executives, involving loss of time and considerable expense, necessary. Considerable expenditures incurred in company's own offices assembling voluminous statistical data, appearing to have doubtful use. Regulation specialist, knowing ropes, smooths way for executive's appearance; advises when to and when not to appear; able to smell out unecessary requirements and concessions; and knows commissioners and their individual views. Regulatory agencies, being quasi-judicial, have different approach to law from courts; therefore, not understood by lawyers trained in business law. Nevertheless, opinions, when contested, are generally sustained. Regulatory specialist trained in current approach to governmental agencies knows what they can demand, understands their trends and can prepare evidence accordingly. Regulation expert might be given managerial position of importance. Notable difference, however, between him and financial and legal experts. Question whether the need for regulatory advice is somewhat temporary and might be obviated or reduced by change in practice and policies of regulatory bodies. Commission members seldom equipped with practical business background or thoroughgoing knowledge of economics, tending to operate by theory. Ample evidence of what regulation by theory has done to utilities. Easy to deduce what management by theory would

produce. Probably addition of regulatory experts to management would not solve problem; better to attempt education of public and regulatory bodies to inconsistent aspects of present regulatory procedure. Some company reports to stockholders now show cost of compliance with requests and orders of regulatory commissions. Regulation experts cannot be cure-all of troubles of utilities.—*Samuel A. Evans.*

Water Works Advancement in the Southwest Through the Short Course. Southwest W.W.J. **22:** 9: 11 (Dec. '40). *Louisiana.* FRANK W. MACDONALD. La. Short Course part of 4-point program for instruction and advancement of water and sewage works operators. Program consists of: (1) school held at La. State Univ. each yr.; (2) annual conference; (3) district schools; and (4) voluntary certification. District schools conducted by instructor of State Education Dept. *Oklahoma.* EDWARD R. STAPLEY. In '35 through advice and co-operation of plant supts. and operators, chart of proposed training program set up, with work through '41. Program divided into basic, technical and operations courses; basic courses covering fundamentals of math. and elementary science to be covered in local classes, others in short courses. 24 1-day conferences held in 24 cities of state each yr. Schedule and subjects taught in courses given. Felt that some good accomplished, with good deal still to be done. *Arkansas.* W. R. SPENCER. Since '18 no. of communities served by water works increased from 58 to 173, supplying water to 90% of urban pop. of state. Improvements made at cost of nearly $8,000,000. Development of professional pride in work noticeable among operators; resulted in organization of water works school in '30 (now called W. W. and Sewage Conference). Conference supplemented in '39 with series of 1-day schools which have been successful. Voluntary licensing plan approved in '40. *Texas.* LEWIS DODSON. First w. w. short school sponsored by Texas Health Dept. in '18. Annual meetings more in form of schools than conventions; plan each yr. has been to make it of practical benefit to operator and in turn serve general public. Attendance at '40 school was 295. Since '35, schools held at Texas A. & M. College where classrooms and labs. available. Proceedings of each meeting published since '26. Assn. has also published popular *Manual for Water Works Operators.* Among advancements obtained through school has been adoption by State Health Dept. of numerical rating system of water supplies and district short schools. Program now has 3 instructors and in 4-yr. period, 41 regional water schools have been conducted with total enrollment of 2,422. Instructors also visit plants and aid operators. Schools have resulted in formation of regional or district assns. with monthly meetings. In Tex., short course has gradually evolved into continuous course of study which will in very near future meet objective of fully trained personnel in all plants of state.—*Martin E. Flentje.*

School for Operators of Water and Sewage Plants. CHARLES L. WALKER. Can. Engr., **78:** 9: 16 (Sept. '40). To improve qualifications of operators, some states require licensing and more than half offer operators training and instruction. Forms of instruction include lecture courses of 1–3 days duration, lecture and lab. courses of 1–2 wk., and evening courses of 2 evenings per wk. for 4 wk. Correspondence courses have been considered and are contemplated by Univ. of Fla. In some instances, fees and expenses have been met by municipality. In others, municipality has provided substitute attendant, and operator has paid own expenses and fees, latter ranging from $1 to $20. There is tangible evidence, in increased interest of operator in his daily tasks, of value of short courses. Supervising agencies notice marked improvement. As licensing and grading of operators increase, there will be increasing need for such schools. —*R. E. Thompson.*

Licensing and Certification of Operators of Water and Sewage Plants. J. B. BATY. Can. Engr. **78:** 9: 18 (Sept. '40). Consistent with continued efforts to improve quality of public water supplies is trend

toward employment of competent operating personnel. No reason why operators should not be required to show definite qualifications in regard to training or experience or both, and their capabilities should be recognizied through certification by organization qualified to judge them. A.W.W.A. Com. Rept. quoted to show extent to which certification has been adopted, and excerpts from licensing law in N.J. which was first state to adopt practice, are given. No Canadian province has adopted plan as yet but it is being considered in Ont. and Que.—*R. E. Thompson.*

When Employes May Recover Compensation for Illness. Leo T. Parker. Munic. Sanit. **11:** 337 (July '40). In some states munic. employees are protected specifically against illness, as well as accidents, and may recover compensation for either disability. In many others, insurance against illness depends upon whether testimony proves disability arose from accidental circumstances. Important to know rule is well settled that contracts of insurance and state compensation laws are construed by higher courts in consideration of meaning of terms and clauses in policy or law. Such terms given effect of their plain, ordinary and popular meaning. Illustrations follow: In *Chase* v. *Business Men's Assur. Co.*, 51 Fed. (2nd) 34, it was disclosed that munic. employee was totally and continuously disabled from performing any and every kind of duty pertaining to his occupation. Subsequently, he died. Disability and death were caused by typhoid fever from drinking polluted and contaminated water. Insurance policy contained clause specifying employee was insured against loss resulting from bodily injury effected solely through accidental means and *not* by disease. Higher court refused compensation saying there was unintentional introduction of typhoid bacilli into body, which set up disease of typhoid fever, and which itself caused physical impairment resulting in death. No bodily injury caused by accidental means. Even if assumed that typhoid fever or infection is bodily injury, policy by its express terms provides that accident insurance shall not cover any injury caused directly or indirectly by any disease. In *Burns* v. *Assurance*, 16 N.E. (2nd) 316, disclosed that sewer pipe broke and in sewage were ameba which eventually infected drinking water. Employee who contracted disease from drinking water sued to recover compensation under insurance policy which insures against "accidental bodily injuries." Higher court refused to hold he was entitled to recover compensation for illness, saying break of pipe was accidental. When he drew water from faucet he expected it to be pure. But for breaking of sewer pipe and subsequent infecting of water system, it is to be presumed it would have been pure. Certainly, disease, such as pneumonia or typhoid fever, is not thought of in everyday language as bodily injury. In ordinary sense, contracting of infectious disease, through the normal consumption of food, air or water infected with bacilli which causes such disease, not regarded as suffering of bodily injury from accidental means, but rather as contracting of disease. In case of *Insurance Co.* v. *Portland*, 221 Fed. 552, under accident policy, court allowed employee compensation for disease contracted by drinking polluted water. Court said that if, instead of containing typhoid germs, as in present case, water that employees of assured consumed had contained some most virulent poisons, no one would contend injuries resulting therefrom could not be properly held to have been accidentally inflicted.—*Ralph E. Noble.*

Health Hazards of Electric and Gas Welding. J. A. Britton and E. L. Walsh. J. Indust. Hyg. & Toxicol. **22:** 125 ('40). First impression of welding processes with exposure to blinding white flame and high temps. is suggestive of risk. Review of literature indicates that potential hazards are numerous, while many types of intoxications and diseases have been ascribed to work. Some description is given of types of welding and of materials used. Both electric arc and oxyacetylene flame give temps. as high as 3,315°C. Of gases

which may be generated, oxides of nitrogen are most important, but do not cause danger except when welding is done in confined space with inadequate ventilation. Carbon monoxide also may be formed, but with ordinary precautions offers no serious menace. Lead fumes arising from coatings of paint on plates which are being welded have been known to cause grave trouble. Most obvious risk is to eyes; but in intensity of hazard lies safety, since no man can work unless his eyes are protected by an adequate colored-glass screen which absorbs ultra-violet, visible and infra-red rays. Medical examination with x-ray was made of 286 welders of 5 or more years' experience. Result was entirely favorable. No disease entity was discovered; nor were any changes of note found in chest. Disability frequency rate was not above that of a control group. Undoubtedly hazards exist with any type of welding; but they are mostly obvious and proper safeguards are taken for their control; hence they should offer no serious menace to health.—*B. H.*

Proposed Standard Helps Reveal Causes of Accidents. ANON. Indus. Standard. **11:** 253 (Oct. '40). Majority of occupational accidents involve both unsafe act and mechanical or material cause, when records are analyzed according to Proposed American Recommended Practice for Compiling Industrial Injury Causes (Z16.2) of A.S.A. Unsafe acts found in 87% of reported cases, mechanical causes in 78%, hazardous arrangement or procedure in 34%, defective agencies in 18%, unsafe apparel in 15% and improper guarding in 9%. Most important unsafe act was unnecessary exposure to danger, found in 26% of all cases; then improper use of or unsafe tools in 16%; non-use of safety devices in 15% and unsafe loading in 10%. Lack of knowledge or skill was major personal cause, being found in 48% of all cases. Improper attitude was indicated in 31% and bodily defects in 3%. 1940 edition of *Accident Facts* gives data on all types of accidents. Trend of accident rates sharply downward. Type accident occurring most frequently varies in different industries.—*Homer Rupard.*

The Five-Day Week in City Employment. ANON. Pub. Mngmt. **22:** 131 (May '40). In at least 9 cities, Chicago, Detroit, Los Angeles, Minneapolis, San Francisco, Seattle, Rockford (Ill.), Essanaba (Mich.), all municipal employees are on a 5-day 40-hr. week; in other 5 cities, of which article summarizes experiences (Cincinnati, Reading, Sacramento, Schenectady, and Everett (Wash.)), 5-day week applies to limited number of employees. Of 120 private N. Y. City area concerns surveyed in '39, 87% had adopted 5-day week effective throughout yr., and in $\frac{2}{3}$ of these companies, this applied to all employees. In municipalities, 5-day week adopted in many cases with understanding no increase in employees would be needed; in Chicago, Detroit and Milwaukee it was, however, necessary to hire more. Most city budgets have been about the same as before plan went into effect; municipal depts. have had little difficulty adjusting operating methods to plan. Plan has improved employee morale. Problems of administration policy such as disposition of hours formerly worked on Sat., taking care of depts. requiring opening on Sat. morning, handling of 24-hr. services, etc. do not appear to be difficult to solve, judging from experiences of 14 cities reported on.—*Martin E. Flentje.*

How the Bell Telephone System Standardized Its Business Papers. J. J. MURPHY. Indust. Standard. **11:** 221 (Sept. '40). System uses 5,000,000 lb. of paper annually. First approach to problem was in '17. Western Electric Co. contracted to centralize purchase of printed business papers for two associated companies. Some economy, but no standards or system resulted. Numerous brands, sizes, weights and colors of paper were specified with little means for determining basic quality of any item. Paper usually bought by brand basis. Few consumers made tests and few instruments were available if they did. A. T. & T. engrs. decided to establish range of standard papers and found that adequate range was available among commercial grades. Paper mfg. processes are simple and generally similar. Variation in quality of pulp used reflects

in finished product. Chemical pulps are sulfite, sulfate and soda. Sulfite is used for most business papers. Sulfate makes brown wrapping paper. Soda is used only in combination with others, having little strength, but is opaque. Rag pulp produces highest grade papers. 13 original standard grades have been expanded to 23. Paper strength varies with humidity. Air-conditioned labs. have allowed uniform testing, where formerly requirements were placed low enough to pass tests under worst conditions. Testing instruments and devices for 10 measures of quality now used. Samples need not be depended upon. Forms have been changed to cut from standard sheets. Use of colors was minimized since significance is lost if used too much. After standard forms are established, master plates are made and become company's property. These are available to any printer bidding on form. Usage determines quantity printed. Stocks were normally set for 3 to 4 mo. use. Printer maintains stocks during life of contract as best fits his shop production schedule. Printers favor plan and are able to submit low bids. Price for forms now based on sq.in. area. Definite scales of prices set for all operations. Pricing of new forms made easy under procedure. General plan has resulted in annual savings of several millions of dollars for Bell System. Good grades of paper are assured and orderly buying procedure has been set up.—*Homer Rupard.*

Water Works Economy Through Electric Operation. Lee Harvey. Am. City. **55:** 10: 52 (Oct. '40). Ave. citizen is interested principally in 3 things in connection with public water supply system: (1) he wants pure and safe drinking water; (2) he wants adequate house pressure with sufficient reserve to take care of fires; and (3) he wants economy in operation so rates will be as low as consistent with good service. At Conneaut, Ohio, all 3 considerations taken into account when new plant was built in '34. Electric automatic operation has played important part in increasing pressure over entire city from 5 to 20 lb. per sq.in., and in reducing operating costs about $5,000 per year (an important amount in a city of 10,000).—*Arthur P. Miller.*

The 1940 National Electrical Code. Alvah Small. Indust. Standard. **11:** 234 (Sept. '40). 1940 ed. was adopted Aug. 7. New rubber compounds for insulation of conductors that may operate at temps. up to 75°C. are permitted, thus allowing increased current carrying capacity. Limited recognition is given to new compounds that reduce required thickness of insulation. Synthetic compounds are recognized. Parts of code rewritten and edited. Hollow spaces in cellular steel floor construction for raceways recognized. Code is prepared by 60 sub-committees, one to each section of code, and then reviewed and approved by Electrical Committee of National Fire Protection Assn.—*Homer Rupard.*

Water-Bill Problems Solved by Triplicate Bills. John H. Burwell. Am. City. **55:** 11: 53 (Nov. '40). New meter billing system in Schenectady, N. Y. typewrites bills, record sheets and journal sheets in one operation. Journal sheets are inserted in electric typewriter remaining there until filled. Triplicate bills are lined up on record sheet and then both slipped in front of journal sheet. Typewriter is then locked and information typed. System works well and covers about 98% of meter readings; exceptions being corporation bills, for which several meters have to be grouped to allow minimum rates.—*Arthur P. Miller.*

Cost and Consumption of Canadian Water Supplies. A. E. Berry. Can. Engr. **78:** 11: 11 (Nov. '40). Extensive tables of consumption and costs in Canadian municipalities are given and discussed. Consumption data for 104 communities varying in population from less than 1,000 to more than 1¼ million. Per capita consumption varies from 28 to 427 and averages 109 g.p.d. Division of list into 3 population groups, namely, 20,000 and over, 5,000-20,000, and under 5,000, indicates that there is no wide difference between consumption in large and small communities, ave. rates being

114, 103 and 110 g.p.d. per capita, respectively. Largest cities, Montreal and Toronto, have per capita consumptions of 94 and 114, respectively. Consumption on max. days is in vicinity of 150% of ave. and on min. days 60–75% of ave. Cost data, for 111 municipalities, are classified as follows: (1) debt charges (principal and interest or sinking funds), (2) all other expenditures, for convenience called "operation and maintenance," and (3) total expenditure. Cost per capita and per 1,000 gal. delivered is given for each classification. Ave. per capita total cost is $4.83 per yr. In 2 largest cities, per capita cost is $4.02 and $4.90, respectively, but cost per 1,000 gal. is identical, 11.7¢. Ave. per capita debt charge is $1.97, or $2.14 if systems free from debt are excluded. Latter figure represents 44% of total per capita cost. In some municipalities, total cost per 1,000 gal. is remarkably low, 3–4¢, but, in most cases, this is explained by fact that filtration is not employed, system is gravity one, or debt charges are low. Wide gap between low and max. costs: majority would fall between $0.08 and $0.15 per 1,000 gal. Ave. for 34 of larger communities is $0.1375. Tabulated data, summarized above, given also in W.W. Inf. Exch., Canadian Sect., A.W.W.A. **3**:B:5:18, **3**:B:6:22, **3**:B:7:26, **3**:C:8:28 (Nov. '40).—*R. E. Thompson.*

The Tax Dollar and the Private Dollar. Henry Traxler. Pub. Mngmt. **22:** 136 (May '40). Theoretically tax and private dollar same—both buy services and materials. In practice suspicion exists tax dollar is different and partly wasted. Author believes public money purchases more than private dollar if spent individually for same services. Huge and costly business mistakes not publicized; similar occurrences, if taking place in municipal expenditures, would be widely known. Many new governmental activities now engaged in; ave. taxpayer does not know his city engaged in 12 or more necessary separate businesses, most of which he has asked for and insists upon. Comparison made of typical annual per capita service costs with per capita expenditure for luxuries and pleasure, some being: education, about $13 per capita; beer, $12.80 and $10 additional for liquor; fire protection, $3.20; candy, $3.50; police protection, $1.68; movies and theaters, $2.80; highways, $2.27; cigars, cigarettes and tobacco, $9.50; etc. Believed city costs, as they stand, represent bargain for what they bring in the way of necessary public activities. To assure ourselves tax dollar buys its money's worth, it should be placed in hands of honest, competent, and trained public officials.—*Martin E. Flentje.*

Technicalities of Water Rights. Leo T. Parker. W.W. Eng. **93:** 1458 (Nov. 20, '40). Numerous kinds of water rights exist and these often subject of litigation. Discussion given of several recent important higher court decisions relative to such rights. Well settled doctrine of law that there may be valid conveyance of water or water rights separate and apart from land. Eminent domain laws authorize public utilities to appropriate private property for public purposes; may also obtain certain limited rights to land—these called "easements." Agreement between upper and lower riparian owner by which lower owner conveys to upper owner right to discharge waste products, sewage, and refuse matter into stream is easement which eliminates usual right of lower property owner to complain, and binds him and his heirs, administrators and successors as well as subsequent purchasers. One decision of this nature made in N. D. court in '40. Each riparian proprietor has equal right to reasonable use of water running in natural course through or by his land for every useful purpose to which it can be applied, whether domestic, agricultural, or mfg., providing it continues to run without material diminution or alteration and without pollution. Considerable controversy has arisen from time to time over exact and legal meanings of terms "spring," "stream," "well," etc.; terms not held to be same or inclusive. Modern courts hold term "person" to mean any person, firm, partnership, assn., corp. or business trust. Examples given of illustrative cases and decisions. —*Martin E. Flentje.*

Promoting Taxpayers' Interest in Their Water Supply. CHARLES SCHWARZLER. J.N.E.W.W.A. **54**: 428 (Dec. '40). Water works operators have a commodity to sell and therefore face same problems as mfr. User must be interested in commodity and his "willingness to pay" gained. Means of advertising at disposal of works officials that require thought and work but relatively little financial expenditure. Water depts. that have made definite bid for public interest have experienced much less difficulty with delinquent bills, complaints and objections to taxes for expansions and rebuilding. Program should start with training and education of employees. Office should be neat and have atmosphere of welcome, personnel of complaint dept. should be composed of most tactful and courteous persons available. Plant should be of such appearance that it will be its own best witness to ability to deliver clean, palatable product. Warning and explanatory signs should be worded to give welcoming feeling rather than to create antagonistic atmosphere. Good relations with newspaper important. In new plant, layout should include: (1) neat, workmanlike but not pretentious plant; (2) inclusion of safety and display features; (3) plant that will emphasize and help sell product. Plant should hold "open house" 365 days each yr., intelligent educational guided trips through plant provided, and every effort made to display product in manner to impress visitors with its purity.—*Martin E. Flentje.*

Good Public Relations—The No. 1 Asset. PAUL KILLIAN. W. W. & Sew. **87**: 431 (Sept. '40). Non-competitive nature of utilities makes good public relations essential. Complaints must be handled promptly and courteously. Excessive bills require special attention before and after presentation. Writer accompanies them with letter offering co-operation in leak detection. Meter readers must be wide awake and well-informed. Examples of local newspaper ads are included. Most important to good public relations are: give good service, and be courteous.—*H. E. Hudson, Jr.*

CORROSION AND CORROSION CONTROL

Corrosion Control by Water Treatment. CHARLES R. COX. W. W. Eng. **93**: 1514, 1575 (Dec. 4, 18, '40). Extent of serious corrosion of water piping seldom realized; effects of such action 3-fold, consisting of: (1) deposition of rust and tubercles reducing carrying capacity of pipes; (2) failure of pipe through pitting; and (3) solution of metal, manifested by staining, discoloration, etc. Two remedies available: (1) use of resistant materials for *both* distr. and plumbing systems; and (2) chem. treatment. Metals used in mfg. pipe all dissolved in water to some extent, rate of soln. very low in many cases. Corrosion avoided by use of non-metallic piping materials; artificial coatings on pipe; removal of either O or CO_2, or both; increase of alkalinity and pH. Effect of corrosion measurable in several ways: inspection of inside surfaces—probably most accurate and definite; detn. of friction loss, increase in Fe content, and loss of D.O. Attempt made to arrive at economic losses due to corrosion in several ways, considering power savings or cost due to friction losses. Of methods to keep loss down, such as chemical treatment, cleaning, etc., lime treatment probably shows lowest overall cost. Most waters devoid of dissolved oxygen are non-corrosive when pH is above about 7.0. Waters having alky. of about 80 p.p.m. and CO_2 content 3–5 p.p.m. not corrosive to metal, water with such alky. and with CO_2 over 5 can be treated by aeration alone. Aeration of soft waters will increase corrosiveness by increasing O content. Lime, soda ash, caustic soda or beds of limestone or marble may be used to remove CO_2, method preferable to aeration when calcium content is low and CO_2 must be available to react with added alkali to form a protective $CaCO_3$ film. Sodium silicate used in few cases to form protec-

tive film, sodium hexametaphosphate recently introduced for corrosion prevention. Review of calcium carbonate films and methods of providing given, together with discussion of methods of feeding required chemicals.—*Martin E. Flentje.*

Corrosion Control With Threshold Treatment. G. B. Hatch and Owen Rice. Ind. Eng. Chem. **32:** 1572 (Dec. '40). Threshold treatment (TT) with sodium hexametaphosphate (HMP) in concns. of 0.5 to 5 p.p.m. not only stabilizes waters which tend to precipitate $CaCO_3$ but also has marked inhibitive action on corrosion of iron and steel. Using black iron pipe, lab. tests showed qualitative inhibition of corrosion by TT. Lab. tests made by passing treated and untreated Pittsburgh tap water through column of steel wool confirmed these results when decrease in D.O. of water was used as measure of corrosion. Apparently decrease in corrosion is due to adsorption of HMP or complex thereof on metal or metal oxide surface. Protective film is fully developed between pH 5.2 and 10.0, and at constant rate between pH 6.4 and 10.0. Although formation of protective coating is slow with 0.5 p.p.m. of HMP (since effect is cumulative), if coating is developed with 4 p.p.m. of HMP, it can be maintained with 0.5 p.p.m. dosage. For given dosage of HMP, coating forms more rapidly at high than at low flow rates, since more HMP is brought into contact with metal surface. Corrosion rate rises only slowly when HMP is discontinued, due to slow removal of protective coating. Action of HMP is less marked in protection of previously rusted than on clean metal surfaces. Application is very simple; any solution feed proportioning device of reasonable accuracy can be used, since intermittent variations in feed are not critical if average remains fairly constant. HMP must not be applied before coagulation or cold lime-soda softening since both are inhibited somewhat.—*Selma Gottlieb.*

Experiences With Corrosion Control at Biddeford, Me. Edwin T. McDowell. J.N.E.W.W.A. **54:** 288 (Sept. '40). Difficulty with discolored water experienced in sections of distr. system of Biddeford and Saco Water Co., supplying local beaches and summer resorts, following installation of new purification plant in '37. Trouble more pronounced in fall and winter during low consumption periods. Substitution of lime for soda ash for pH correction solved problem after plant difficulties with feeding lime and determining correct application points were corrected. Lime dose now split, part added in clear well and part to water just after mixing. pH 8.4–8.5 being maintained.—*Martin E. Flentje.*

Methods of Determining the Protective Value of Paints. C. M. Angel et al. Am. Ry. Eng. Assn., Bul. 421 ('40) p. 227. After describing in detail various types of paint failures together with current methods for testing, it is suggested that contract for large paint supplies be awarded on basis of results from accelerated weathering tests, with due consideration for economy.—*R. C. Bardwell.*

Soil Corrosion of Metals and Cement Products. Anon. Wtr. & Wtr. Eng. (Br.) **42:** 324 (Sept. '40). Distribution of various clays and sands, regarded likely to affect buried pipes, etc., are shown on map of England. Great part of country is covered with inert superficial deposits. In some sections "corrosive" beds largely covered by superficial deposits. Each site should be investigated on grounds to ascertain whether pipes were laid in material of formation given and that corrosion was not due to outside causes. Appears that nitrates that have affected buried metals are not indigenous to sub-soil, but are of organic origin. Sub-soils of impervious nature are likely to keep salts near surface. Certain types of sub-soil support corrosion more than others. Outstanding conditions that produce corrosion appear to be: (1) bad drainage; (2) presence of sulfates or sulfides; (3) chlorides; (4) soft water; and (5) nitrates. Absence of all may result in soil being noncorrosive. Argillaceous formations support conditions (1) and (2), to which the conditions are practically confined.

Condition (3) is not common, but is known in both arenaceous and calcareous beds. Condition (4) is extremely rare, and is found only in arenaceous beds. Broadly speaking, slates, clays, shales, and marls may be regarded as corrosive formations; and sands, sandstones, and limestones as non-corrosive. Drift formations may not be corrosive except, for example, boulder clay with a matrix of sulfate-bearing clay. In the top soil, conditions that affect corrosion differ from those in the sub-soil. Top soil corrosion is, in some cases, concerned with formation of nitrates. Humic acids, although perhaps in themselves not harmful to metals, may, by action on mineral salts (or manures) in soil, produce acids that are corrosive. Corrosion of metals, buried at shallow depths, should be considered as a problem distinct from that of more deeply buried metals.—*H. E. Babbitt.*

Investigation of Soils With Respect to the Protection of Pipe Against External Corrosion. G. M. TIEMERSMA-WICHERS. Korrosion u. Metallschutz (Ger.) **16:** 39 ('40). Physical characteristics of 11 soils investigated, including quantitative determination of grain size, plasticity, complete Proctor data and cohesion of kneaded soils under water. All uniform loam and clay soils containing not too much bog material or humus are suitable for protective wrapping of pipe. Bog soils or bog-derived clays are generally unsuitable. To serve as protective wrappings, soils should be kneaded with as much moisture as possible and, if they lose cohesion under water, about 5% cement should be added. Proctor and grain-size diagrams of soils are given. —*C. A.*

Effect of Humidity on Corrosive Activity of Soils. A. V. SOLOV'EV AND A. A. LUBIMOVA. Compt. Rend. Acad. Sci. (U. S. S. R.) **27:** 136 ('40). Clays and black soil from Moscow and saline soil from Caspian lowlands show max. corrosion of cast iron (as measured by loss in weight of cast-iron strips during 94 days at approx. 18°C.) at humidity contents corresponding to individual water-absorption max. of soils. Decrease in corrosion of cast iron above max. is probably due to diminished access of air to metal; result is a decrease in depolarization.—*C. A.*

Investigation of the Corrosion of the Baku-Batum Pipe Line. A. V. SOLOV'EV. Neftyance Khoz. (U. S. S. R.) No. 2: 42 ('40). Corrosion is greatest in moist ground, high in salts and in air permeability. Severe corrosion is observed on intermittent moistening and drying, as in gulleys, river valleys, etc. Red iron oxide coatings are very unstable in corrosive soils because of acids in soil. Alkalies saponify the drying oil and react with lead soaps. Bitumen layers protect pipes better with increase in thickness of film layers. Severe corrosion is observed in soils containing, simultaneously, sulfates and chlorides of alkali and alkaline earth metals. Very hygroscopic chlorides promote corrosion by sulfates and other salts. Anaerobic processes also favor corrosion of metals in ground. Local elements can be depolarized by anaerobic processes. Aqueous extracts of rust formed on pipe have varying pH values. Local corrosion of pipe takes place if acidic rust is formed. Soils are classified according to their corrosive action.—*C. A.*

Tufaceous Deposit on a Sand Strainer in a Borehole for Water. F. H. EDMUNDS. Wtr. & Wtr. Eng. (Br.) **42:** 323 (Sept. '40). Thin, transverse section of incrustation on brass sand strainer in a well in calcareous sands of Corallian formation in Oxfordshire, were examined under microscope. Deposits consisting of crystalline calcium with a slightly radial arrangement, and with some inclusions of a black substance, were shown. Material is essentially tufaceous coating which has been deposited in layers from solution. Chem. analysis shows (in per cent): silica, 0.60; oxides of iron and alumina, 8.08; calcium sulfate, 0.86; calcium carbonate, 88.07; organic matter, 2.39 and trace of sulfide. Periods of heavy pumping would account for periodicity of deposition, but no proof that any connection exists between pumping and tufa deposition. Strainers with small apertures will become blocked by

tufaceous incrustation more rapidly than those with larger openings. Some method of back-blowing with a weak acid may be a possible cure.—*H. E. Babbitt.*

Studies in Microbiological Anaërobic Corrosion. Publication, Tech. Sec., Am. Gas Assn. ('40); **Microbiological Anaërobic Corrosion of Steel Pipe Lines.** Oil Gas J. **38:** 1J: 92 ('39); **The Microbiological Corrosion of Natural-Gas Pipe Lines.** Gas. **16:** 7: 36 ('40); **Methods of Studying Microbiological Anaërobic Corrosion of Pipe Lines.** Petroleum Engr. **11:** 6: 171; **11:** 7: 112 ('40). *All articles by* RAYMOND F. HADLEY. Microbiological anaërobic corrosion only one of many types of pipe line corrosion. Among others are following: stray current electrolysis, acid, carbon contact, differential aeration. Microbiol. type not ordinarily encountered in industrial processes but is surprisingly frequent as natural occurrence, accounting for considerable of corrosion of buried ferrous metals. Subject of interest to any technologist engaged in protection of sub-surface properties. Importance and extent of problem illustrated by several tables showing results of inspections of long steel gas lines in Ohio, Pa. and N. Y. Of total pipe requiring protection against corrosion during period '36–'41, from 20% to 100% (of various lines) required such protection because of bact. action. Theoretically corrosion of ferrous metals under strictly anaërobic conditions in neutral homogeneous soils or aqueous solns. should ordinarily be negligible and of minor importance. Establishment of presence of *Sporovibrio desulfuricans* type bacteria, however, gives basis for explanation of how this type of corrosion can proceed. Bacteria provide necessary factor of hydrogen depolarizing agent (hydrogen acceptor) and at same time produce reaction product which is capable of precipitating ferrous (Fe^{++}) ions as highly insoluble ferrous salts. Microbiol. anaërobic corrosion similar to electrochem. corrosion; differs only in method by which activity of corrosion couple is maintained. Theory first expounded by Dutch scientist Von Wolzogen Kuhr, following study of graphitization of cast-iron water lines in Holland (1923). Theory briefly states that hydrogen polarization of cathodic areas of iron buried in ground can, under anaërobic conditions, be broken down (hydrogen removed) by action of group of organisms known as sulfate-reducing bacteria. Cathodic hydrogen is used by bacteria in reduction of combined oxygen in SO_4 (sulfate) ion and results information of hydrogen sulfide (H_2S) and H_2O. Iron (Fe^{++}) ions present are precipitated by H_2S as ferrous sulfide and also as ferrous hydroxide. Resultant lowering of soln. pressure of iron together with removal of cathodic hydrogen, which, if not removed, would have retarded corrosion, causes corrosion of iron to proceed at rapid rate. Steps may be shown as:

$$4Fe + 8H^+ \rightarrow 4Fe^{++} + 8H \text{ (anodic soln. of iron)}$$

$$H_2SO_4 + 8H \rightarrow H_2S + 4H_2O \text{ (depolarization)}$$

$$Fe^{++} + H_2S \rightarrow FeS + 2H^+ \text{ (pptn. of iron)}$$

$$3Fe^{++} + 6(OH)^- \rightarrow 3Fe\,(OH)_2 \text{ (pptn. of iron)}$$

or entire process as:

$$4Fe + H_2SO_4 + 2H_2O \rightarrow 3Fe\,(OH)_2 + FeS.$$

Experience has allowed formulation of several rules: (1) for bacterial corrosion to succeed, necessary for ground to be airtight or water saturated, but not necessarily inundated; (2) pH of soil water must be approx. 7.0, limiting deviation noted ±0.8 pH; if pH above, action unlikely, if within range, action may or may not be present depending on availability of organic food material. Sulfate-reducing bacteria grow within wide temp. range, have been found between 0° and 80°C.; in size are 2μ to 5μ long by 0.5μ wide, readily visible under 850 magnification; are gram-negative, shaped generally as vibrio (curved rod) or spirillum (coil spiral). Can be grown in culture soln. containing: tap water, 1,000 ml.; K_2HPO_4, 0.5 gram; NH_4Cl, 1.0 gram; NA_2SO_4, 1.0 gram; $MgSO_4 \cdot 7H_2O$, 2.0 grams; $NaC_3H_5O_2$, 3.5 (× 1.4); $CaCl_2 \cdot 2H_2O$, 0.1 gram. Soln. sterilized in autoclave, boiled just before using and cooled rapidly to remove dissolved O; pH adjusted to 7.5, poured into 60-ml. bottles and 5 to 10 mg. crystal sterile

Mohr's salt added. In locations where this type corrosion occurs, possible to determine by analysis of corrosion products. Microbiol. anaërobic corrosion always accompanied by formation of iron sulfide; field test with hydrochloric acid found to be very useful. Acid forms H_2S with corrosion products; can be recognized by odor. Complete chem. anal. better, but time consuming. Pit depths where bact. corrosion present greater than where such action absent. Steel pipe of 4 mm. thickness shown to have failed from active bact. corrosion within 7 yr.; action not of "self-healing" variety; in fact, pit-depth rate curves have shown pronounced increase with time in some locations where bact. corrosion active. Effect of cathodic protection not entirely determined as yet; H formed may be expected to increase bact. growth. On other hand growth may be prevented by raising of pH to beyond growth point. Protection against this type of corrosion can best be accomplished by complete insulation from ground and soil water. One company is using petroleum asphalt around pipe encased in a wooden box of durable wood. Pipe supported and centered with porcelain cleats of low porosity. Method in successful use for 9 yr. Advisable not to leave grass, weeds, leaves, roots and wood in contact with pipe, as this may lead to severe active local corrosion of pipe. Cellulose of these materials acted upon and decomposed by saprophytic bacteria and decomposition products used by sulfate-reducing group. Author hopes more information, which is badly needed, regarding this type of corrosion may be forthcoming.—*Martin E. Flentje.*

Corrosion of Iron in Water. *Effect of Small Concentrations of Sodium Silicate.* Dante J. E. Veronelli. Industria y Quim. (Argentina) **2**: 182 ('39). Review of essential facts and decisive factors in corrosion of iron in water is followed by description of original experiments with water containing small concentrations of sodium silicate. Such additions lead to increased pH and even greater reduction of corrosion; iron is given protective iron silicate film, even after metal has been taken out of solution and placed in pure water. With increasing temp., iron corrosion increases at slower rate in solution than in pure water. Effect of sodium silicate is more pronounced in water containing large amounts of dissolved oxygen and in distilled water than in ordinary water. 38 refs.—*C. A.*

Corrosion Troubles in Heating and Hot-Water Systems. L. Kenworthy. J. Inst. Heating & Ventilating Engrs. (Br.) **8**: 15 ('40). Use of copper, iron, brass, lead and galvanized parts is discussed. Any increased corrosion of galvanized parts as result of using copper pipes is almost entirely due to extremely small amounts of copper dissolved by water, direct electrolytic effect due to dissimilar metals in contact being negligible. As little as 0.05% copper can cause considerable corrosion of galvanized iron. Attack becomes more severe as copper content of water increases. Analyses of waters indicate which are suitable for these bi-metal systems. Dezincification is especially prone to occur in 60/40 brass. With 70/30 brass it can be overcome by addition of trace of arsenic in metal and by keeping impurities low. Water high in chlorides favors it. Lead failures are usually due to intercrystalline cracking. Creep can also stimulate corrosion. Traces of zinc in lead pipe can cause rapid deterioration. Corrosion of lead pipes from outside can occur in an alkaline environment.—*C. A.*

Disturbances by Copper in Hot-Water Generating Plants and Their Elimination. L. W. Haase and P. V. Dardanelli. Korrosion u. Metallschutz. (Ger.) **16**: 150 ('40). Apparatus for investigation of copper-dissolving properties of various types of water and their corrosiveness toward iron described. Amt. of copper going into soln. depends on acidity of water, copper area and time of contact. Attack of iron by hot water depends on amt. of copper deposited on iron and not on that in solution. Copper is not deposited on rusty surfaces and newly installed pipes may show more severe attack than old ones. Protective layers can be formed in which lime and

silica predominate. While sand filters improve waters of relatively low corrosiveness, filter materials which yield alkali and absorb copper ("Magno" materials) should be used for aggressive waters.—*C. A.*

The Change of the Zinc Potential Toward a Nobler Value in Hot Tap Water. G. Schikorr. Metallwirtschaft. (Ger.) **18:** 1036 ('39). In hot tap water, zinc can become nobler than iron. Explained by fact that above 60°, corrosion products of zinc are deposited in very dense adherent form. Apparatus used for measuring potentials is described. Failure of pipes in certain spots is attributed not to material flaws but to combination of unfavorable conditions; *e.g.*, it is assumed that when air bubbles are present, zinc coating may be destroyed before protective film can be formed and that later, when air is swept away, corrosion can proceed unhampered.—*C. A.*

Preventing Corrosion in Cooling Systems. F. J. Matthews. Mine and Quarry Eng. **5:** 200 ('40). Corrosive tendencies due to free acidity or presence of unstable minerals in water can be combatted by giving water a definite alky. Dissolved CO_2 should be removed with lime and dissolved O is best handled by addn. of tannin extract or Na_2SO_3. Treatment with dichromate forms oxidized film over metal surface and inhibits corrosive action. Naturally soft water should be regarded with suspicion; whereas a zeolite-softened water usually is sufficiently alkaline that it will not cause trouble.—*C. A.*

Refrigerating Brines. D. W. Haering. Power Plant Eng. **44:** 12: 71 (Dec. '40). Author claims factors influencing corrosion by refrigerating brines are D.O. and pH. Ammonia leakage in brine systems may cause excessively high pH. CO_2 leakage causes reduction of pH. Above pH 9 galvanizing may be attacked and below pH 8 iron and steel are attacked. Exception is calcium or magnesium brine where pH values must be carried at 7 or below to avoid precipitation of magnesium. Application of corrective brine treatment should be based on analysis by responsible lab. and recommendations from competent specialist. Chrome glucosates recommended.—*T. E. Larson.*

Notes on Corrosion Control in Refrigeration Condensers. K. M. Holaday and A. Von Gontard. Ice & Refrig. **98:** 286 ('40). Various methods of reducing corrosion in refrigeration condensers were studied. Proper control of carbonate balance in circulating water eliminated serious corrosion. When water had pH of 9.2 to 10.1, corrosion rate was low without excessive scale formation.—*C. A.*

Cathodic Protection Surveys. Harry J. Keeling. Gas. **16:** 10: 33 ('40). 1.1-v. range of portable potentiometer was insufficient for measuring some pipe-soil potentials. Accordingly, range extension was provided, adding total of 10 v. in 1-v. stages, without changing either sensitivity or accuracy. Resistors used on extension were adjusted to accuracy of 0.01% and extension unit required balancing only once every 2 to 3 hr. Except for very rapidly changing potentials, rarely encountered, potentiometer has inherent advantages over other pipe-soil potential measuring instruments in that it draws no current, is rugged, permanent in calibration and has longer scale length.—*C. A.*

Determining Minimum Current Required to Provide Adequate Cathodic Protection. Dave Harrell and Milton Clerc. Petroleum Engr. **11:** 1: 38 ('39); **11:** 4: 64 ('40). At 25°C., min. protective potential between pipe and soil is —0.5705 v. with reference to normal electrode. Below protective figure, metallic iron deposits, and above it, gaseous hydrogen is evolved. Value was calculated theoretically. Lab. tests give experimental results which are in close agreement. Protective potential is straight-line function of temp. Temp. corrections are made from given equation.—*C. A.*

Zinc for Cathodic Protection of [Steel] Pipe. W. T. Smith and T. C. Marshall. Gas Age. **84:** 4: 15 ('39). Zinc anodes applied to bare steel pipe buried

in alkaline soil give effective protection against corrosion at ¼ current density required when external power supply is used. Current densities such as to maintain steel at 150-200 mv. negative to soil are applied. Technique described in detail.—*C. A.*

Cathodic Protection for Prevention of Corrosion of Steel Water Tanks. H. E. SILCOX ET AL. Am. Ry. Eng. Assn., Bul. 414 ('40) p. 97. After describing application of cathodic protection to typical railway steel water tanks, it is concluded that period of operation to date has been so limited that more time will be required to demonstrate whether this method is satisfactory in preventing corrosion in steel water tanks.—*R. C. Bardwell.*

Cathodic Protection of a Bare 24-Inch Steel Line (Buried in Soil). T. C. MARSHALL. Gas Age **83**: 8: 13 ('39). Carbon anodes buried in trenches filled with coke breeze are placed at 50 or 100′ intervals alongside the pipe, and d.c. voltage of 5v. is applied by means of rectifiers. Extra anodes are placed in particularly corrosive soil, *e.g.*, near salt spring. Corrosion is prevented if pipe is maintained at not less than 125 mv. neg. to soil. Power consumption is 0.5-1 kw. per mi.—*C. A.*

Cathodic Protection and Polarization of Underground Pipe Lines. R. J. KUHN. Oil Gas J. **38**: 19: 98 ('39). Theory of galvanic action of buried pipe lines is outlined. Formation of film of hydrogen and an alkaline scale in cathodic areas causes polarization, which prevents pitting and corrosion. Conditions affecting polarization are reviewed.—*C. A.*

Cathodic Protection of Oil-Storage Tank Bottoms. DONALD H. BOND. Petroleum Engr. **11**: 6: 100 ('40). Forty-five 55,000-barrel tanks have been successfully protected from corrosion by cathodic protection from four 15-volt, 100-amp. generators during 3-yr. test. Installation of cathodic protection units is described and diagram of system is included. All tank bottoms and connecting pipe lines had ave. negative potential of 0.8 v. or more. Metal-to-ground potentials on outside angle-iron of tank bottoms should ave. approx. 0.05 v. more negative than accepted potential value for complete protection in order to ensure full protection at center of tank bottoms.—*C. A.*

Cathodic Protection of Condensers and Coolers Utilizing Brackish Bay Water. W. A. S. WRIGHT AND J. H. BROOKS. Refiner Natural Gasoline Mfr. **19**: 202 ('40); Oil Gas J. **39**: 3: 60. Red-brass condenser tubes pitted and failed in short time where brackish water was used. Situation markedly improved by installation of admiralty tubes with cathodic protection. Cast-iron anodes supported on "Micarta" insulating rods threaded into heads. Anodes externally connected in parallel. Copper oxide rectifier used to supply current at 5-10 v. —*C. A.*

Cathodic Protection of Natural-Gas Pipe Lines. H. C. GEAR. Petroleum Engr. **11**: 12: 29 ('40). Cathodic protection system employed by Lone Star Gas Co. to protect 3.5-mi. section of pipe line is described and illustrated. Sources of d.c. are 3 natural gas-driven engines having 2,000-watt capac., with top output of 100 amp. and voltage of 5-35. Permanent anodes are located 500′ from line. Entire system is watertight and provided with connection on end of riser to allow addition of brine solution in case of resistance increase due to drying. Potential curves before and after installation of system on line shown. Cost and economics of system discussed at length.—*C. A.*

The Results of Some Corrosion Tests of Metals and Alloys in the By-Product Coke Industry. O. B. J. FRASER AND G. L. COX. Proc. Am. Gas Assn. p. 605 ('39). Samples of 21 metals and alloys assembled in spool-type holders were exposed at points of severe corrosion in various by-product installations. Measurements made of loss of weight of samples, and results recorded in terms of inches penetration per yr. Tests were made in ammonia liquors both in presence and absence of tarry matter, in an

ammonia liquor drain table, ammonia liquor coolers, at bottom and top of phenol distillation tower, in light oil washer, benzol agitator, acid regenerator plant, benzol still, ammonium thiocyanate regenerator, and in coal-tar stills. Monel metal is shown to be useful in contact with sulfuric acid, ammonium sulfate, ammonia liquor, alkaline solutions, tar acids, and salt and polluted waters. Inconel and stainless steels resist corrosion in benzol and coal-tar distillation equipment and in locations where sulfur dioxide may be present.—*I. M.*

Corrosion of Metals and Alloys by Flue Gases. Proc. Am. Gas Assn. p. 542 ('39). *Appendix I.* Louis Shnidman and Jesse S. Yeaw: Samples of 15 metals and alloys were exposed in asbestos-board chambers to flue gases from sulfur-free natural gas and from odorized natural gas containing sulfur 0.4 grains/100 cu.ft. Samples were removed monthly, cleaned, and examined for loss of weight and depth of pitting. Results are compared with those from previous tests in flue gases containing sulfur 9 and 330 grains/100 cu.ft., respectively. Stainless steel (18:8) is most corrosion-resistant material in all conditions. Lead, which resists corrosion well in gases of high sulfur content, is particularly liable to pitting in purer gases. Aluminum and chrome iron also show pitting in these conditions, but to less serious extent. From tests, table is given showing life expectancy of sheets 0.032 in. thick of various metals when exposed on one side only to flue gases. Additional tests on samples exposed without cleaning for 16 mo. indicated that whereas in these conditions ave. depth of corrosion is less, pitting is more severe, and useful life is probably unaffected. *Appendix II.* E. J. Murphy: Samples of 9 metals and alloys were suspended from rotating arms in 2 water-sealed bell-jars provided with vertical cooling coils which promoted fog formation. Jars were supplied for 8 hr./day with flue gases, and for remainder of time specimens were exposed to water-saturated air. One jar was supplied with gases collected from referee burner and contained sulfur compounds, other with synthetic mixture of similar composition but free from sulfur. Loss of weight of samples was determined after 1 yr. Stainless steels of 18:8 type entirely unaffected. In sulfur-free gases, galvanized iron was corroded most severely, followed in order by Wilder metal, copper, and lead-covered copper. In burnt gases, attack was more intense but nearly in same order, exceptions being that Wilder metal was more severely attacked than galvanized iron. —*I. M.*

The Corrosion of Iron Electrodes by A. C. in Aqueous Electrolytes. J. W. Shipley and G. R. Finlay. Can. J. Res. **17:** 99 ('39). Describes investigation into corrosion of iron electrodes in electrolytes of different composition and concentration when 60-cycle 110-volt current was used. Voltage sufficiently high to produce phenomena of boiling, arcing, and gas formation which accompany generation of steam in electric boiler of resistor type. In 0.1 *N* solutions of salts, rate of corrosion increaseP in electrolytes in following order: magnesium sulfate, calcium chloride, sodium hydroxide, sodium bicarbonate, sodium carbonate, magnesium chloride, sodium chloride, ferrous sulfate, sodium sulfate, ferric chloride. Rate of corrosion varies both with nature of electrolyte and with concentration. When electrolyte contains calcium or magnesium, film of calcium or magnesium may be found over surface of electrode, protecting it from corrosion. Expts. with natural waters also indicated that waters containing these metals were relatively non-corrosive. Increase in concentration of salts increased arcing and corrosion. Arcing found to increase corrosion. Arcing occurs across bubbles of gas; bubbles can be suppressed by operating boiler under pressure; therefore suggested that steam generators be operated at pressure sufficient to prevent steam formation and that hot water be allowed to vaporize under reduced pressure in separate chamber. Tests on protection by addition of substances to electrolyte showed

that magnesium sulfate or chloride gave best results.—*W. P. R.*

Corrosion by Cavitation and by Impact of Liquid Drops. P. DE HALLER. Schweiz. Arch. (Ger.) **6:** 3: 61 ('40). Blades of hydraulic turbines, screws, pumps, etc., working at high speed, frequently show peculiar form of corrosion—or erosion—which has been found to be due to bubbles of vapor, forming in regions of low pressure and collapsing in regions of high pressure, giving water-hammer effect. Expts. in which this effect is produced by rapidly moving liquids, or by vibration of the test-piece at high frequency, or by pressure waves in liquid are described. Erosion has been found in Pelton wheels to be due to impact of liquid droplets, and expts. bearing on this are described. Effect of nature, structure, and surface finish of test-piece is discussed.—*I. M.*

Tarnish and Corrosion on Galvanized (Iron) Sheets. F. R. MORRAL. Zinc Inst. Preprint. (Apr. '40). Exam. by x-rays and electron-diffraction beams shows that hot, freshly galvanized sheets develop a transparent oxide film within 4-8 sec. of leaving pot; film is about 1000 Å thick, but in presence of moisture and absence of carbon dioxide it grows until it becomes visible as a yellowish-brown tarnish, although it is not converted into hydroxide. In presence of moisture and carbon dioxide, film becomes converted into basic zinc carbonate, $2ZnCO_3 \cdot 3Zn(OH)_2$, so-called "white rust." Pure zinc or galvanized sheets develop on exposure to ordinary atmosphere a transparent film of basic zinc carbonate which appears blue by light-diffraction effects. Finger-print marks on hot galvanized sheets consist of basic carbonate with outer layer of basic zinc chloride. Yellow oxide film which forms on hot sheets is as protective to corrosion as blue film formed on cold sheets.—*I. M.*

Protection Against Corrosion of Large Pipes. RESSMANN. Gas u. Wasser. (Ger.) **83:** 393 (Aug. 10, '40). In Hamburg, large pipes protected by applying, with a brush, 2 layers of a paste composed of equal parts of alumina cement and fine sand. Coating sticks solidly to clean iron pipe and is highly resistant to chem. influences. No corrosion found after several years in service.—*Max Suter.*

An Improved Holiday Detector for Testing Pipe Lines. HARRY J. KEELING. Gas **15:** 6: 33 ('40). Improved form of spark-type holiday detector was developed for finding holes or weak spots in pipe coatings. Cast aluminum frame was supplied with tufts of steel bristles so mounted that entire pipe was covered. Heavy-duty spark coil fed with three 3-v. batteries was used, one high-tension lead being connected to cast aluminum frame through neon sign cable and other lead trailing along ground. Neon lamp was used as indicator.—*C. A.*

DAMS

Dam Foundations. Some Recent Examples in British Practice. W. L. LOWE-BROWN. Civ. Eng. (Br.) **35:** 229 (Aug. '40). Where rocks, such as granite, silurian rocks, strong millstone grit, etc., in which there may be fissures, are found at or near surface of ground, concrete or masonry dam is frequently adopted. Such a base, although strong enough, may, nevertheless, be far from impermeable; in which case a cut-off trench is excavated. Fine fissures containing water under pressure may be stopped by grouting before dam construction is commenced. Area of base downstream of cut-off trench is drained by series of drains conducted beyond downstream toe. Frequently connected to pillar drains. Cut-off wall is carried to impervious layer below dam, and beyond ends of dam to prevent outflanking. Under conditions of wet-foundations may be necessary to sink no. of shafts on or near line of cut-off trench, and to use them alternately as wells, from which ground water can be

lowered, and as shafts from which sinking can be continued. Grouting procedure depends on overburden, underlying strata, fissures, etc. Bore holes grouted before cut-off trench has been excavated; after construction of trench but before construction of wall; and sometimes after sufficient concrete has been laid to resist upward pressure. When leaks are discovered, it is usually due to undetected defects in strata. At Ryburn Dam, no grouting was done until cut-off trench filled with rich concrete to sufficient depth to prevent uplift. At earth dam for Bartley reservoir, ground consisted of thick beds of impervious marl, with alternate beds of sandstone. Primary bore holes were first drilled and grouted at 90′ intervals. In disintegrated granite, in Cornwall, which is both fissured and porous, bore holes of 4″ diam. were drilled to give cores. Cement was injected into bore holes under pressure for each 10′ of depth, until no more cement could be taken. Inclined holes at an angle of 45° were also found advantageous in such mixed strata as disintegrated granite. *Discussion: Ibid.* **43**: 26 (Feb. '41). J. Noel Wood: Most striking modern development in dam construction has been use of cementation. Late Thomas Hawksley used cementation in about 1878 at one of Rochdale reservoirs. Pressure cementation first applied in England in sinking of mine shafts. Interesting to note how present practice of cementation as applied to dam foundations has evolved. Procedure adopted at Brownhill Res. was to grout before cut-off trench was excavated. Use of percussive drilling not only cheaper than rotary drilling but has additional advantage that there is less tendency for grout to choke than in holes larger than 1⅞″. Delwyn G. Davies: From performance of eng. structures, which is more informative than any amount of theory, 3 conclusions may be drawn: (1) every dam is potential menace to community below; (2) ultimate stability depends very largely on judgment and experience; and (3) rare occurrence of failure and its accompanying but undeserved publicity is acknowledgment of general safety of dams. Probably most dangerous conditions are found in horizontal strata with few vertical fissures, e.g., shales, limestone, and sandstone. Terzaghi has shown that horizontal limestone is satisfactory if joints are open and closely spaced. Ideal foundation profile coincides with trajectory of second principal stresses so as to be normal to that of the first principal stress. Advantage of rising grade and dangers of falling grade in dam foundation evident. Following empirical formula is suggested as rough basis for comparison between different dams: $Q = KAh$, in which Q is leakage through dam, A is area of exposed face, h is hydrostatic head for laminar flow, and K is leakage factor. E. W. Denholm: Pressure grouting, if improperly carried out, can cause additional fissures which are ultimately filled at expense of considerable quantity of cement, or can give results which may not be an improvement. Appears to be very good case for leaving grouting until definite leakage figures before and after cementation can prove value of operations both structurally and economically. In initial grout mixes and pressures in cases quoted, water-cement ratio appears to have varied between 26:1 and 4:1. Appears to be little relationship among 4:1 mix at pressures up to 200 lb. per sq. in. in 60′ holes; mix only ⅓ of that strength at higher pressure in 20′ holes; and 15:1 mix in 100′ to 150′ holes at 30 lb. per sq. in. Explanation would prove valuable. A. R. Needlands: Greater part of injection is now done through small-diam. percussive holes, rotary holes being practically confined to those where cores are required. Pressure has to be adjusted in accordance with geological conditions. Pressure in horizontally-bedded shale must be adjusted to depth at which injection is carried out and kept as low as possible to prevent uplift with consequent cement wastage. At other extreme, igneous rock with fine fissures may require pressures of 700 lb. per sq. in. or more. Employment of lubricants both restricted and improved. Cementation is one of those arts dependent on operative skill and knowledge. Watertight cementation barrier

can be constructed in nearly every class of strata. Have never known of instance where cementation was not much more economical than excavation and concreting. Latest figure, for pre-war prices were 12s 6d per cu.yd. in compact rock with fine fissures, to 30s in open ground or badly fissured rock. *Author's Closure:* With regard to formula given by Davies, would hardly serve as yardstick for leakage under and around foundations. Use of clay-puddle in cut-off wall is not so universal as it was before beginning of century. In relation between water-cement ratio and pressure used for grouting, no rules of universal application can be formulated when conditions of dam sites display such wide variations.—*H. E. Babbitt.*

Masonry Dams. *A Symposium.* Proc. A. S. C. E. **66:** 812 ('40). *Basic Design Assumptions.* IVAN E. HOUK AND KENNETH B. KEENER. Adequacy of site constitutes first fundamental criterion for design of masonry dam. Gravity structure is only as stable as base on which it rests. Basic assumptions involved in design of important masonry dams are: (1) rock which constitutes foundation; (2) bearing power of geologic structure along foundation; (3) homogeneous and uniformly elastic rock formations; and (4) flow of foundation rock may be allowed for by a lower modulus of elasticity than would otherwise be adopted in technical analyses. Masonry dam, as constructed by most approved methods is today a safer and better-understood structure. Inherent limitations of concrete in respect to volume constancy have been largely offset by use of special cements. Use of lean mixes, containing large-size aggregates, has made uniformity of all ingredients and close control of concrete manufacture imperative. Improvements in conveying concrete have included substitution of buckets, pumps, and other preferred methods of transportation for belt conveyors and chuting systems. Normal dead loads include concrete weights, gates, bridges, or other superimposed features, and weights of such materials as may be deposited on sloping faces of dam. Structural action of masonry dam in transmitting dead and live loads to foundation and abutments is much better understood and much more carefully analyzed than it was a few years ago. In '33, the late D. C. Henny proposed a method for calculating factor of safety against downstream movement, based on shearing friction factor of safety. Important development in design has been gradual improvement in methods of analyzing stress conditions such as effects of foundation and abutment deformations and methods of determining true nonlinear distribution of stress within structure. Trial load method of determining nonlinear stresses in interior of masonry dam is based on adjustment of horizontal and vertical beam deflections at all conjugate points in interior of dam and in large foundation block which is included in analysis as an integral part of structure. *Design of Arch Dams.* R. S. LIEURANCE. *Ibid.* **66:** 829. An arch dam is a structure that transmits total water load to abutments by arch action. Ideal site is a canyon having a small ratio of length to height and having reasonably sound abutments which are so nearly symmetrical that symmetry can be produced with a small amount of excavation. Structure to be analyzed is inherently as complex as the distribution of forces. Choice of section for a given site depends on its individual characteristics. Zone of higher stress is likely to occur at about two-thirds of height of structure, at which point most of load is carried by arch action. Appendix includes 14 tables for use in designing circular arches, 2 being necessary for each load. *Preparation of Foundations.* CHARLES H. PAUL AND JOSEPH JACOBS. *Ibid.* **66:** 852. Main considerations are: (1) bearing capacity; (2) bond; (3) sliding resistance; (4) control or reduction of uplift pressure; (5) prevention or control of seepage; and (6) prevention or control of scour from overflow or outlets. Term "bearing capacity" is used to indicate supporting characteristics of rock over large areas. Tight bond can be secured if rock surface is absolutely clean. Grout wash or mortar coat spread immediately preceding placing of masonry gives added assurance of accomplishing desired result. On firm,

hard rock, where tight joint can be secured, there is no danger of sliding at contact surface. Grouting foundation seams, and combination of a grout curtain and drainage, are usually relied upon to control or reduce uplift. Measures taken to control uplift help to prevent or control seepage. Hydraulic jump principle is basis of more common methods to protect against scour. Importance of thorough preliminary surface and subsurface explorations is obvious. Diamond drill, shot drill, and some of newer devices with cutting points of special alloy steels are used for exploratory drilling, mainly, in sedimentary rocks. Purpose of core drilling is to secure undisturbed samples, to predetermined depths, of foundation rock. Large shot drill has become almost indispensible in examination of important foundations. Term "rough excavation" refers to the removal of all overburden and, furthermore, to removal of those portions of immediately underlying rock that are soft or otherwise unsuitable for foundation purposes. This is to be distinguished from scaling and trimming which is final step in rock excavation. Following scaling and trimming, foundation surface should be cleaned of all loose particles, including very finest of chips, sand, and dirt. All-important elements of foundation grouting include pressures, grout consistency, and speed of injection. Provision for drainage is now practically universal practice in dam construction. In general, problem of preparing abutments is based on same requirements as that of preparing remainder of foundation. Building of low masonry dams on sand and gravel foundations opens up special field in dam design and construction. As to bearing capacity, a well-graded and compacted sand and gravel foundation may be sufficient for very low dams and for dams of moderate height which follow slab-and-buttress type of design or some similar special design which reduces unit stress by spreading load on foundations. There can be no effective bond between sand and gravel foundations and masonry of dam. Resistance to sliding, where piling is not used, may be developed by broadening base. Seepage is usually controlled by sheet-pile cutoffs. A common measure of uplift pressure is obtained from a hydraulic grade line starting at elevation of full reservoir and ending at elevation of tailwater. Where a river-channel spillway section is part of design, protection against scour is best controlled by a well-designed stilling pool. Shale and other stratified rock require special study because of diverse characteristics and liability of finding soft or permeable seams between harder layers. Stratified rocks are likely to be weak against attack by scour. *Geological Problems of Dams.* IRVING B. CROSBY. *Ibid.* **66:** 869. Every dam rests upon geological formations which are stable but which, when dam is finished and reservoir is filled, are subjected to new and different conditions. Design must be such that formations will continue to be stable. In preliminary investigation to select best site, much information can be obtained by physiographic study of area. In second stage, first step is geologic mapping of site and vicinity. Geophysical prospecting may be used in preliminary investigation and in some cases in more detailed study of dam sites. "Electric coring" has recently been applied to dam site investigations. First problem is selection of site with best bedrock profile. Buried valleys are common in glaciated regions. Sometimes such features will show up well in aerial photographs. Among geological features of importance are: faults, crush zones, joints and zones of close jointing, bedding seams, sharp folds, deep weathering, zones of alteration, solution channels and cavities, and lava tunnels. Resistance of rocks to erosion is important in regard to effect of overflow on rocks below spillway. Shale probably requires greater care and more precautions in preparation of foundations than any other rock. Principal practical problems of masonry dams on sandstone are seepage, uplift, and sliding on bedding seams. Greatest danger of failure on siliceous, calcerious, or ferruginous sandstones is from sliding. Principal practical problems of dams on limestone and other soluble stratified rocks are leakage and sliding on shaly bedding seams. Dams on gypsum pre-

sent even more serious problems than those on limestone because of much greater rate of solution of gypsum. Problems of dams on lava are principally concerned with loss of water, and this may not necessarily occur at dam site, because they are generally highly fractured. Problems of dams on granites and other intrusive igneous rocks are similar to those on lava. Principal practical problems of dams on slate or schist are sliding and stability of abutments. Dams may fail from many causes due to many types of defects of the foundation rocks, but there is nothing mysterious about these failures. *Concrete Control.* I. L. TYLER. *Ibid.* **66:** 891. Concrete in dam construction must have strength to carry loads; weight to provide safety against sliding and overturning; durability to insure against weathering and erosion; impermeability; and continuity so structure may act according to assumptions of design. Cement for large dams, in addition to having properties assuring strength, durability, and impermeability of concrete, should have a low rate of heat evolution and a low total heat liberation. Low-heat cement may be expected to replace other types except in locations where portland-pozzolan cement may be more economical. Fineness of cement has been shown to have a marked effect on physical properties of fresh concrete in which it is used. Aggregates may be of two general types—natural or manufactured. The former are found in river or glacial deposits. Manufactured aggregate crushed from suitable deposits of various types of rock has been used successfully for some time. Ample provision for drainage of aggregate to constant moisture content is necessary. Mixing water should be tested for impurities of harmful nature. Probably the best known and most used grading formula, in the proportioning of concrete, is the familiar

$$p = \left(\frac{d}{D}\right)^n$$

in which p is the proportion passing a given screen size d; D is the maximum size of the aggregate; and n is a factor roughly measuring harshness of the mix. Modern batching equipment provides means for adding water in accurately determined amounts. Placement of concrete should follow immediately after spreading the mortar, covering grouted area as soon as possible. In general, surface vibration should be avoided because of danger of bringing mortar to surface and remixing it with accumulated water. Cracking in concrete may be due to temp. effects, foundation deflections, load deformations, or a combination of these. Cracking of concrete in thin sections due to moisture volume changes is difficult, if not impossible, to eliminate. For extremely large dams artificial cooling is almost necessary if groutable contraction joints are to be obtained within a reasonable length of time after completion. In preliminary studies, various properties of concrete usually considered are as follows: durability; workability and bleeding of fresh concrete; cement requirement; unit weight; compressive strength; elastic and plastic properties, Poisson's ratio; permeability; volume change due to temp. and moisture changes; thermal properties; and temp. conditions in masses. Advances made in the art of building concrete dams indicate that future progress may be rapid. *Construction Joints.* BYRAM W. STEELE. *Ibid.* **66:** 908. In dividing a dam into monoliths, or blocks, ideal spacing of vertical construction joints normal to axis of dam would be dimension that varied from block to block to suit profile of dam site and type and height of dam. At present 15 m. in foreign countries and 50′ in U. S. seem to be most popular spacings for vertical joints normal to axis of dam, with general requirement that each joint shall extend entirely through structure. Trend towards closer spacing of joints is also evident in concrete pavement construction. Joints are either plain or keyed and, if keyed, there may be few or many keys. It is now generally conceded that elimination of keys on horizontal lifts of mass concrete is desirable. Ideal dam should have neither transverse nor longitudinal joints or cracks. Thin arches which will cool to mean annual temp. through-

out entire mass during construction period would seem to offer most attractive field for slot rather than grouting method of joint treatment. Where future differential movement of surfaces of vertical joint parallel to plane of joint is anticipated, use of some form of asphaltic or bituminous compound, with or without asbestos fiber, may be desirable. Bonding vertical surfaces is not so common a requirement as for inclined or horizontal surfaces. Metal strips at horizontal construction joints and elaborate cleanup requirements are gradually disappearing from construction practice. An absolutely watertight permanent membrane would be desirable on upstream face of any dam but whether it is necessary and worth the cost is open to question. There is preference for some kind of water stop across all transverse joints near upstream face. Indiscriminate use of joint fillers is objectionable from standpoint of appearance; and in many instances there is no basic reason for use. Successful grouting of joints is a highly specialized line of work, greatest detriment to success being leakage around or through grout stops. Height of lifts has varied through rather wide limits, in practice, with probably more yardage placed in 5′ lifts than in any other. Appendix contains extensive data on 78 masonry dams. *Discussion. Ibid.* **66:** 1379. William P. Creager: As regards pressure of silt, attention has been called to Goldbeck cell measurements in cores of the Miami and Tieton dams to indicate that horizontal pressures did not exceed "hydrostatic pressure" after consolidation had taken place. Investigations were conducted to show that Goldbeck cell measurements did not prove lack of soil pressure. Due to seepage friction losses, water pressure at any point is less than that corresponding to total head above that point. Total water and silt pressure acting on upstream face of concrete dams depends upon relative permeability of silt and that of foundation. Writer believes that permeability of silt may be negligible in comparison with that of most rock foundations, and that, therefore, pressure of silt is not negligible. In writer's opinion, shearing strength of many classes of horizontally-bedded rock foundations is unknown since it is impossible to determine extent of weaknesses in such bedding planes. If shearing along a weak bedding plane would result in quite a flat surface, a "toe-hold" or some other form of anchorage would be necessary. George R. Rich: The presence of random shrinkage cracks serves to vitiate much of the refinement in computations based upon elastic theory, and, in serious instances, to invalidate even simplest stress determination. Reduction and elimination of such defects appear to present most important current challenge to engrs. engaged in dam construction. In constructing Hiwassee Dam, crack-prevention measures adopted, in order of importance, were: (1) low-heat cement; (2) slow pouring program; (3) low proportion of cement in concrete mix; (4) artificial cooling of concrete; and (5) use of cooled mixing water in summer. More consistent results and greater economy, without sacrificing safety, will be obtained in predicting loading conditions during earthquakes by basing analysis upon properly selected period and amplitude for ground motion and calculating extent to which response of structure approaches resonance, rather than by applying more or less arbitrary lateral loading of 0.1 gravity. With respect to articulations or flexible joints in arch dams, it is undesirable to sacrifice any part of structural strength of dam to simplify its analysis. In investigating thick arches of relatively sharp curvature, it may be desirable to take account of fact that neutral axis of arch does not coincide with gravity axis. May be accomplished readily by well-known Cain-Jakobsen formulas. Familiar Westergaard formula for hydraulic super-pressures during earthquake shocks should be reconsidered concurrently and possibly modified in case of thinner arch dams. In spite of powerful methods available there still remain numerous possible combinations of effects that must be covered, for present, by liberal margin of safety. Robert A. Sutherland: In certain cases interpolation in tables presented by Lieur-

ance's paper may give incorrect values. Difficulty may be overcome by means of curves covering range of values which depart appreciably from linear variation. Deflection tables may also be extended to express deflections as percentage of radius, if a certain modulus of elasticity is assumed. For many purposes, such tables are valuable in giving stresses directly, with absolute minimum of labor. Comparison between stresses obtained by direct computation from original Cain formulas, from Fowler's curves based on revised Cain formulas, and from Lieurance's tables shows first method is matter of 2 or 3 hr. work for each elevation. Other methods require minutes only. ROSS M. RIEGEL: One aim of process of foundation treatment should be to develop shearing strength, as well as bearing strength, at and below contact. Process of cleaning out and grouting horizontal seams increases strength of foundations as well as bearing strength, and finds justification therein. Most competent and continuous supervision possible should be feature of dam site exploration so that significance of core losses can be determined with greatest certainty. Frequently, loss of core may be avoided by improved processes. Tendency to larger holes has brought about 36″ and 40″ drills. Direct evidence afforded by inspection of interior of such a hole is convincing and authoritative. PAUL BAUMANN: Approx. solutions for joint spacing may be obtained. Are, however, of doubtful value. For example, block between two joints may be considered as monolith. According to evaluation of modulus of elasticity, and other factors, proportionality factor varies from about 0.6 to 1.2 and, therefore, would lead to wider joint spacings than are generally used. Although attention given to spacing of joints normal to axis has often been wanting, has been even more so in regard to joints parallel to axis. Longitudinal cracks, vertical and inclined, were observed in remaining block of St. Francis Dam after its failure. Some drained water stored inside block for several days after failure. Writer believes that shape of abutments has much to do with cracks normal thereto. Hence, in giving due attention to configuration of final abutment excavation, and particularly by avoiding abrupt changes in slope as well as by avoiding convexity, most of causes of cracks may be eliminated. As to radial joints in arch dams, it is believed that slots on radial planes should be used unless very good reasons to contrary. Unless straight gravity dam is designed to resist earthquake forces when under influence of uplift, keys should be provided for purpose of mutual support and continuity between blocks. Purpose of attaining safe and permanent mass concrete structures is, aside from carefully designed and treated joints, served by using concrete of moderate ultimate strength and by placing it with as little water and as much care as practicable. W. A. PERKINS: Design of construction joints is matter that requires far more attention than received in past. Desirable to begin all radial contraction joints at foundation. Joints in original O'Shaughnessy Dam were placed radially with spacing at upstream face of 97′. Numerous inspection wells and galleries are provided in dam. Since completion of work in '38 no cracks discovered. Use of slots, instead of contraction joints, for closure of dam does not necessarily guarantee that transverse cracks will not develop at some subsequent time. Mortar that is spread on cold joint ahead of concrete pour should be of practically same mix as mortar of concrete being used. Serious objection to use, as a water stop, of copper sheet bent in U-shape with two long wings buried in concrete. If leak develops value of entire water stop is lost. L. J. MENSCH: No doubt that any dam, whether a gravity or arched structure, with proper abutments, will act like a curved plate; but plate has cracks and joints in 3 directions and only safe way is to judge structure as if built of jointed brickwork. Boulder Dam acts as a curved plate and not as a gravity structure, notwithstanding that base is $\frac{9}{10}$ of height. As far as writer can see, will take many years yet before stress problem of high dam will be solved to satisfaction of conservative engrs. Joints and cracks cannot be prevented in dams

and designer must take this fact into consideration. Water stops of metal are another perplexing problem. Asphaltic joint fillers have not proved successful in most joints. Wood planks make cheaper and better filler. LEWIS H. TUTHILL: Two important aspects of fundamentals of good concrete making for masonry dams. First is importance of uniformity of aggregate and other is lag between what is known and should be done about concrete control and what is actually done about it on the job. *Ibid.* **66**: 1697 (Nov. '40). BERLEN C. MONEYMAKER: Thesis, that essential foundation conditions can be determined in advance of construction, that safe successful dams can be built at most sites, and that dam failures are not entirely unavoidable, is now rather generally accepted by both engrs. and geologists. Geologist, however, must bear in mind that geology is not only consideration involved in selection of a dam site. Another geologic feature that may affect dam adversely is sheet jointing or "sheeting planes." No doubt that geologist of today is contributing more to success and safety of dams than geologist of decade ago. A. WARREN SIMONDS: In construction of contraction joints, good design may become of questionable value due to faulty construction at metal seals or by plugging of essential header pipes. In designing grout system for arch dam, height of grouting lift should be governed by stability of blocks when joints are subject to grout pressure. Control of grouting operations should be governed by careful observation for deflection of blocks while grouting. Number of joints that can be grouted in one operation depends on equipment and organization available. Contraction joint grouting system is fairly costly feature of dam construction. W. J. E. BINNIE: Only in comparatively recent years that factors that govern deformation of concrete under any given load have been studied and much is still to be learned. Age of concrete where stress due to water level is imposed can scarcely be same throughout entire structure. If foundations of dam penetrate rock to any considerable depth, concrete becomes well bonded to rock, and effective weight, tending to resist "uplift" pressure, is not only that of dam itself but also that of adjacent rock. In England, geological conditions are generally unsuitable for construction of masonry dams. Practice of slaking portland cement is not now followed in England. Instead, it is finely ground and transverse joints have become desirable. Writer would recommend adoption of articulated watertight diaphragm of high-grade concrete, transmitting thrust to main dam, as considerable economy would be secured by adopting concrete mix of lower grade for latter; and all difficulties with regard to contraction or temp. cracks, which permit percolation, would be avoided. *Ibid.* **66**: 1839 (Dec. '40). **67**: 141 Jan. '41). HOMER M. HADLEY: Mr. Tyler states that, for satisfactory performance, concrete must possess strength, weight, durability, impermeability and "continuity" (freedom from cracks) in order that structure may act according to assumptions of design. Would appear that continuity might well be accepted as satisfactory even if it were of relative rather than absolute degree and that impermeability of structure might be obtained, advantageously and economically, in numerous cases by means other than those of present practice. Possibility, of course, that cracks in dams may become filled with water under pressure. This water pressure in cracks, if they do tend to develop, find relief without causing damage, and that this is not mere wishful thinking is attested by definite evidence. In many places freezing occurs, and then question of possible damage from freezing of water in cracks arises. Small cracks developing in concrete dams are not the desperately dangerous things which so much current practice and discussion indicate. There is a field of usefulness for what may be called a "concrete fill" dam, that is, a heavy gravity section constructed of lean concrete to be built from the bottom up in a single mass, layer by layer, in the same manner that rolled-fill dams are built, with impermeability and durability provided at surfaces of exposure. Such dam, possessed of certain measure of flexibility, could well be

used at sites deemed unsuitable for standard gravity dam or arch. *Ibid.* **67:** 141 (Jan. '41). I. NELIDOV: Writer believes that consideration should be given to effect of Poisson's ratio when designing high concrete dams and especially those of buttress type. May be noted that sliding cannot occur simultaneously with shear, but will begin only after shearing failure has occurred. Consequently, appears that only shearing resistance should be introduced in computing stability. In recent years another problem has become connected with design of high dams—problem of either raising existing dam, or providing for future increase in height. Method used at O'Shaughnessy and Alpine Dams consisted principally of adding slab of concrete to downstream face of existing dam, thus forming inclined joint between old and new concrete. JAMES B. HAYS: Type of equipment best suited for maximum recovery should be used [in core drilling]. Where forms were removed from mass concrete sections 24 hr. after pouring, and water curing started immediately, cracking was noticeably less than where forms were left in place for 2 to 5 days. Writer would add 3 other items to list of 7 of procedures tending toward crack elimination, as follows: (8) early removal of forms and immediate and continued application of curing water; (9) use of absorbent form-lining materials; and (10) selection of proper aggregate. In comparing grouted joints with concrete-filled slots, some advantage in favor of grout, in that open cracks in joint faces of concrete will be filled.—*H. E. Babbitt.*

Construction of New Masonry Dam in England. ANON. Civ. Eng. (Br.) **35:** 307 (Nov. '40). Masonry dam under construction somewhere in England since Aug. '36 and is expected to be completed in early part of '41. Dam is gravity structure with max. water depth of 63′ and top water level of 638′, creating reservoir with capac. of 368 mil.gal. (Imp.). Designed for subsequent additional height of 15′ to increase storage to 900 mil.gal. (Imp.). Trial holes indicated that sound granite rock would be available at not more than 25′ below ground surface. Overlying granite, were hard compact clays and gravels, loose boulders and ledges of rock which rendered use of mechanical excavators almost impossible. During excavation of foundations, river was diverted through channel supported over trench. In layout of plant, anticipated that ample supplies of granite for aggregate, displacers, and masonry would be available near site. Very nearly 60,000 cu. yd. of concrete being used in construction. Displacers up to 5 tons in weight are embedded in concrete. Masonry facing is generally of square, rock-faced granite cut from selected stones. Nearly 30 tons of cement used in cementation of foundation.—*H. E. Babbitt.*

Modern Construction Methods on Earth Dams. O. N. FLOYD. Civ. Eng. **10:** 487, 586 (Aug., Sept. '40). Today, for hydraulic fill to be cheaper than rolled fill, proposed dam embankment must contain generally not less than 10 to 12 million yd. and be located across a wide valley with good hydraulic fill borrow, at least 40′ deep, available for almost full width of valley. With amply safe foundation material upon which to build an earth dam and with proper borrow material for each type of construction, no particular advantage in safety or utility of one type over other, but during construction, hydraulic fill is little harder to control and can become dangerous if not properly handled. On most construction projects where large dam is involved there are other considerations—such as construction schedule arranged to take advantage of dry or low-water seasons and to minimize flood hazards, and co-ordination with other features of project—which must partly govern choice of excavating and earth-moving equipment. Pickwick Landing Dam is good illustration of project where construction features and schedule for more difficult and expensive concrete structures exercised considerable influence on schedule and selection of the plant for earth dam portion of project. Estimates indicated that during favorable weather rolled fill could be placed more cheaply than hydraulic fill, but for filling cofferdam

cells and for excavating below water outside cofferdams for power-house intake and tailrace, and approach channels for lock, dredge would be needed. A second-hand 16" dredge in good condition was purchased for hydraulic fill work. Cost of dredge operation, including depreciation but not including pipe line and placing expense or overhead, was \$0.186 per cu.yd. On north side 304,000 cu.yd. of rolled fill in dam embankment and about 200,000 cu.yd. of common fill in switch yard were placed by dry-excavating and hauling equipment. Generally, material was wet enough, or too wet, so that sprinkler was used very little except on places of concentrated travel where surface became smooth, hard, and dry. Sardis dam was well suited for hydraulic fill construction. Surface material across main valley on which dam rests is silt, loam, and silty clay loam. Hydraulic fill was constructed with comparatively narrow central core which was predominantly of silt. Surplus water was drawn from core pool through 2 low-head, electrically-driven screw pumps, each mounted on small barge in pool. Generally, on each pump, both shell and impeller remained in fair condition until about 750,000 cu.yd. had been delivered to embankment. Departure from conventional practice of building earth dam with central impervious core and pervious shells has resulted in very material saving in cost of Wappapello Dam. Specifications required that material on dam be spread in layers of such thickness that after rolling with usual size and type of sheepsfoot roller, each layer would not be more than 6" thick. As roller tended to keep larger gravel and cobbles in top few inches, suggested that a different type or weight of roller might do better job on this material. Although heavy concrete roller at Wappapello Dam did not give as good compaction as either standard or heavy sheepsfoot roller, that has not been true at some other places where gravel and even sandy shale were being rolled. Writer had many years of experience in building earth dams before anything of practical value was known of modern methods of soil mechanics, and his experience with soil technicians in years past has often reminded him of impressions of 7 blind men who were led out to feel an elephant. Writer pays tribute to few of older soil technicians who have kept their feet on ground and their minds open, and to larger number of able younger ones who are following in their footsteps. Fortunately they have come on scene about time when most of the good sites have been utilized, and their help is needed as never before.—*H. E. Babbitt.*

Fitting Rolled Earth Dams to Local Materials. B. K. Hough, Jr. Civ. Eng. **10:** 689 (Nov. '40). Writer favors policy of exploring materials closest to given site for sole purpose of accurately classifying them with respect to their geological and physical nature and extent and without any preconceived ideas whatever as to their ultimate utilization. In developing final design, nature of development should be considered. Control of seepage may be taken as illustration of importance of exact definition of design requirements. With complete classification of available materials and comprehensive set of criteria before him, designer's job becomes one of choosing most economical section that will utilize the materials effectively. Most elementary of conventional types is so-called homogeneous embankment. More elaborate, but more efficient, design results when both pervious and impervious materials are used. In third type, pervious material in upstream section is replaced with impervious to afford maximum effectiveness in reducing seepage. Of 3 types, homogeneous would be most suitable where foundations are bad. Practice of selecting materials on basis of suitability for earth dam construction should be abandoned in favor of selecting dam designs on basis of suitability for construction with nearest available materials. Intimately connected with requirements that all materials be selected is hazard of unexpected shortage. Difficulty may be expressed in statement that conventional dams usually have no factor of safety against material shortage. If scarcity of impervious material is acute, major reduction in size of core can easily be effected.

Essentially downward, rather than horizontal, direction for seepage is more favorable to stability and may be obtained by inclining core section. When appreciable seepage through foundation is possible, distribution of core material to serve simultaneously as water stop in embankment and as blanket for foundation is advisable. Interior drainage type dam was found to possess surprising degree of stability against wave wash, in comparison with standard dam, when both were tested in model tank. Closely related to design problems is problem of field control. Methods of analyzing compacting effort to obtain tangible basis for ordering more or less rolling or additional wetting or drying, while contractor's equipment is still working, are not believed to be generally available. Degrees of compaction, like design, should be based on definitely established, rationally determined criteria.—*H. E. Babbitt.*

Model Tests of Large Sluice Gates at High Velocities of Approach and With Different Pier Noses. JEFFREY B. MACPHAIL AND RAYMOND BOUCHER. Civ. Eng. **10:** 592 (Sept. '40). Tests were made in hydraulic lab. of École Polytechnique de Montreal, where there is a glass-sided flume 30″ by 30″ in section and 50′ long. Dam under consideration was to discharge with max. head of 31′ through openings of 50′ clear width, controlled by "Stoney" roller gates. Model was built to scale of 1:60, giving 1 full opening of proper size and 2 side openings a little more than ½ width which they should be. Results of tests on 3 different nose shapes differ from one another by not more than 1%. Tests show that discharge coef. for gates at any given head remains nearly constant as long as height of sill is greater than head; and that it diminishes rapidly as sill height becomes progressively less than head. In applying this work to design, usual doubts about possible departure from true similarity in flow arise. In present case, however, true capacity of prototype not of interest until coming of flood much larger than anything yet observed in 40 yr. of record.—*H. E. Babbitt.*

Core Control and Cutoff Construction at Kingsley Dam. W. J. TURNBULL AND GEO. N. CARTER. Civ. Eng. **10:** 623 (Oct. '40). Kingsley Dam is hydraulic fill structure being built as on-river dam across North Platte R. valley about 8 mi. northeast of Ogallala, Neb. In main section, base width is 1,140′ and height, 160′. About 20 million of 26.6 million cu.yd. of dam are now in place, and of this quantity at least 11% is core material. Water table in valley is in general only a few feet below ground surface. In preparing plans and specifications for construction, district's engrs. and consultants worked up suggested method for placement of hill loess material in core section. Core material is delivered dry to hog box and dumped into hopper with two openings at bottom. For control of dredging and core placement operations frequent sampling in core and transition zone sections has been maintained. Ave. depth of core pool is maintained at about 4′. Average consolidation of core as a whole agrees with that anticipated from studies of original borrow material. Minimum safe length of path of percolation of water through Ogallala formation indicated that some type of cutoff would have to be provided for distance of 600′ from end of core. Plan finally adopted was construction of concrete curtain wall with compacted fill on water side. Work on right abutment cutoff was started by drifting into hill for full length of curtain wall (600′). Total quantities for curtain wall included 57,250 sq.ft. of concrete wall, 12,500 cu.yd. of excavation, and 9,000 cu.yd. of imported backfill. Contractor's bid prices were as follows: for concrete curtain wall, $0.70 per sq.ft.; for excavation, $3.50 per cu.yd.; and for imported backfill, $0.25 per cu.yd.—*H. E. Babbitt.*

Cavitation in Outlet Conduits of High Dams. HAROLD A. THOMAS AND EMIL P. SCHULEEN. Proc. A. S. C. E. **66:** 1623 (Nov. '40). Occurrence of severe cavitation damage to concrete surfaces of outlet conduits of Madden Dam supplied incentive to carry on extensive studies by means of lab. models to investigate cavitation potentialities, if any, in con-

duits of Tygart River Dam, near Grafton, W. Va., and to develop methods of eliminating or minimizing future damage in conduits of Madden Dam. After reservoir [at Madden Dam] had been completely drained, conduits were inspected and damage that had resulted from cavitation recorded. Inspection revealed fact that cavitation action had seriously eroded walls and tops, or ceilings, of conduits. Inspection revealed all loose or disintegrated particles of concrete to have been removed by terrific scouring action of water. In effort to find solution to problem of cavitation control, conduit entrances in Madden Dam were revised during spring and summer of '35. Well known that under certain conditions of hydraulic flow, persistent void space or cavity will occur at some given location in stream of moving water. Existence is frequently made evident by vibration of walls of containing vessel and by loud cracking sound known as "crepitation." Where cavitation pocket occurs in contact with solid object, such as concrete surface of conduit or metal blade of turbine runner, solid material ultimately becomes damaged by destructive disintegration commonly known as "pitting." Cavitation may occur at any point in hydraulic system when pressure at that point is reduced to vapor pressure of liquid flowing in system. In course of model studies, tests were made of various methods proposed to eliminate or minimize damage in conduit entrances. Various methods or measures may logically be arranged in 2 general groups: (1) those which have as their purpose provision of conduit boundaries conforming more nearly to paths naturally sought by boundary filaments of flowing water; and (2) those which have as their purpose general adjustment of pressure within entire conduit or upstream part of it.—*H. E. Babbitt.*

ERRATA

1. Page 1952 of the November, 1940, JOURNAL; Equation 2:

$$\text{for}\quad C_{t_0} + T = 2\sqrt{8g}\,\log\frac{3.7D}{\alpha(t_0+T)} \quad\text{read}\quad C_{(t_0+T)} = 2\sqrt{8g}\,\log\frac{3.7D}{\alpha(t_0+T)}$$

2. *Ibid.;* Equation (4):

$$\text{for}\quad \frac{C_{t_0}+T}{2\sqrt{8g}} = p \quad\text{read}\quad \frac{C_{(t_0+T)}}{2\sqrt{8g}} = p$$

3. *Ibid.;* Equation (5):

$$\text{for}\quad 10^{p_0} = \frac{3.7D}{\alpha 10^{p_0}} \quad\text{read}\quad 10^{p_0} = \frac{3.7D}{\alpha t_0}$$

4. *Ibid.;* Equation (6):

$$\text{for}\quad 10^{p} = \frac{3.7D}{\alpha t_0 + T} \quad\text{read}\quad 10^{p} = \frac{3.7D}{\alpha(t_0+T)}$$

5. The titles of Figs. 5 and 6 on pages 281 and 282 of the February, 1941, JOURNAL should be interchanged, the illustration on page 282 being the meter equipment.

APPLICATION FOR MEMBERSHIP
IN THE
AMERICAN WATER WORKS ASSOCIATION

22 EAST 40th ST., NEW YORK

Date: ....

.... hereby make application for
(I or We)

....

(Active, Junior, Corporate or Associate Membership, or Affiliate)

in the American Water Works Association, and enclose herewith the sum of $ ...., one year's dues in advance.

Name ....

Company or Department ....

Title or Position ....

Address ....

....

If application is for Junior Membership, give date of birth ....

If application is for Affiliate, state number of active services in property where employed ....

Nature of business or character of work (for office records) ....

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If application is for Corporate or Associate Membership, it must be signed by the person designated to represent the firm or corporation in A.W.W.A. activities.

....
Signature of Applicant.

Application obtained by:

....

(over)

ARTICLE I OF BY-LAWS

Section 3. An Active Member shall be a superintendent, a manager, an official or employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, or any qualified person engaged or interested in the advancement of knowledge relating to water supplies. (Annual Dues, $10.00.)

Section 4. A Corporate Member shall be a Water Board, Water Commission, Water Department, Water Company or Corporation, National, State or District Board of Health, or other body, corporation or organization engaged or interested in water supply work, and shall be entitled to one representative whose name shall appear on the roll of members, and who shall have all the rights and privileges of an Active Member. This representative may be changed at the convenience and pleasure of the Corporate Member on written notice to the Secretary. (Annual Dues, $15.00.)

Section 5. An Associate Member shall be either a person, firm or corporation engaged in manufacturing or furnishing supplies for the operation, construction, or maintenance of water works. (Annual Dues, $25.00.)

Section 6. A Junior Member shall be an employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, a student or any otherwise qualified person engaged or interested in the advancement of knowledge relating to water supplies. At the time of his admission he shall be not less than eighteen years of age. His connection with the Association shall cease when he becomes twenty-five years of age, unless he is regularly enrolled as a student in a university or has previously transferred to the grade of Active Member. Junior Members shall receive the Journal and all privileges of Active membership except holding office and voting. (Annual Dues, $5.00.)

Section 7. An Affiliate shall be any person otherwise qualified for Active membership who, at the time of application, is not nor previously has been a member of the Association and who, for acceptable reasons, does not wish to become an Active Member.

No corporation, firm or partnership which otherwise would be entitled to the grades of Associate or Corporate member may hold the grade of Affiliate. No employee of an Associate member may become an Affiliate. No person who is the superintendent, the manager, the chief engineer, the superintendent of filtration, the chief chemist, or the superintendent of distribution in a plant having more than 3,000 active services, is eligible for the grade of Affiliate. Under unusual conditions, exception to the above may be made by action of the Executive Committee if the applicant sets forth fully the reasons for the exception when applying for the Affiliate grade.

Affiliates shall not be entitled to vote upon general Association questions, and not eligible to hold office in the Association, nor in any of its Divisions. They shall be eligible to vote upon Section questions and to hold Section offices except those of Chairman, Vice-Chairman, Secretary (and/or Treasurer). They shall be entitled to all other rights and privileges of Active Members. Affiliates receive the March, June, September and December issues of the Journal each year. (Annual Dues, $4.00.)

Memberships will be dated as of the beginning of the quarter in which the application is received.

Membership in the Association carries, also with no additional dues, membership in its Local Sections and National Divisions, and includes the Journal, a monthly publication devoted to water works interest. The proceedings of the annual conventions and of the meetings of the Local Sections are published in the Journal, which also contains contributed articles on subjects pertaining to public water supplies.